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SAN FRANCISCO HARBOR

ITS COMMERCE AND DOCKS

WITH A

COMPLETE PLAN FOR DEVELOPMENT

BEING THE

REPORT OF THE ENGINEERS

OF THE

Federated Harbor Improvement Associations

LUTHER WAGONER
AND
COL. W. H. HEUER, U. S. A.

1908

SYNOPSIS

FOREWORD

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Accompanying this report are the following Charts:

CHART I. Showing existing wharves and slips on the San Francisco water front.

CHART II. Showing complete system of wharves, piers, basins and slips recommended by the engineers of the Federated Harbor Improvement Association.

Parts tinted pink represent areas inside of seawall line now owned or under the control of the State of California.

Parts tinted olive green represent areas in which seawall basins streets and slips are recommended to be built, and in which such areas as are not already controlled should be acquired by the State of California.

CHART III. Statistical Chart prepared from authentic sources and from which many deductions in this report have been made.

CHART IV. Map of San Francisco Bay region, showing San Francisco and vicinity.

To the Federated Harbor Improvement Association.

Gentlemen: In April, 1907, your associations representing various industrial, commercial, banking, real estate and other organizations, requested the undersigned to formulate a plan for the orderly development of the port of San Francisco, based upon a forecast of its commercial requirements fifty years hence; and to make recommendations for suitable docks, piers, seawalls and basins that would afford ample accommodations for all vessels likely to be employed in carrying the commerce of this port; and further to advise such improvements as might aid in providing a safe, rapid and economical method for transferring persons and property between the land and water.

In compliance therewith the following report is submitted. In obtaining data for its preparation Mr. Luther Wagoner visited the principal sea and lake ports of the United States, and many of the important seaports in Europe; and much valuable information was thus obtained.

Grateful acknowledgment is made to the San Francisco Harbor Commissioners, their Engineers, and to Mr. Howard Holmes, to the Chamber of Commerce and the Merchants' Association, and to the Dock Departments in New York City, Philadelphia, Boston and Baltimore, for the data they have supplied, and to the officials connected with the management of the docks at London, Liverpool and continental European ports who have assisted us.

In addition to the general acknowledgment, Mr. Wagoner desires to express his obligation incurred during his recent investigations abroad to the officials of the American Consular service at Genoa, Rome, Marseilles, Havre, Antwerp, Rotterdam, Amsterdam, Bremen, Bremerhaven, Hamburg, Southampton, London and Liverpool, for their courtesy and cordial assistance; and in particular to acknowledge the advice and information given by Mr. Michael Jenkins of Baltimore, Messrs. Mather and Neal of Philadelphia, Mr. John M. Phelan of New York, Mr. Miles Kirk Burton of Liverpool, Mr. J. G. Broodbank of London, Mr. F. Claussen of Bremerhaven, M. Quinette Rochemont of Paris, M. A. Batard Razaliere of Marseilles, and Messrs. I. Inglesi and E. Cagli of Genoa.

PART I.

THEORY OF PORT DEVELOPMENT.

FACTORS OF COMMERCIAL SUPREMACY.

Commodious dockage on deep water is the determining characteristic of a great commercial port. Substantial wharves, of sufficient area for the reception and assorting of merchandise and its prompt transfer to railroads and teams, with adjacent warehouse facilities, are the ultimate demands of a great commerce.

While it is true that ample anchorage, protected from the violence of the ocean weather, and approached through broad and safe channels from the sea, is the primary requisite of navigation, yet it may be stated as a broad generalization that an undeveloped port is of no advantage in the building of a seaboard metropolis nor to the country lying behind, because no matter how great its natural advantages, ships cannot make economical use of such a port.

Three factors determine the commercial supremacy of a city by the sea: First, its potential tributary commerce; second, the size and accessibility of its harbor; and third, the development of its docks to meet the requirements and accelerate the increase of its commerce.

Of the three, the volume of the commerce, actual and potential, is fundamental. Good harbors on barren coasts do not make great seaports. But where a tributary interior territory exists, rich in agricultural and mineral possibilities, and capable of supporting a large population, it is sufficient to transform shallow inlets into deep and commodious harbors at the points where the lines of intercourse of its maritime and interior trade converge. Where the hinterland is rich in resources, and a natural harbor already exists, capable of receiving the commerce of the world, it is evident that the acceleration of the growth of the port will depend on the remaining of the three factors—that is, the development of its docks.

Such are the conditions at San Francisco. Its natural harbor is unsurpassed, and there are no physical limitations to its tributary trade. Its ultimate ascendency will therefore be determined in large measure by the provision of liberal docks and wharves, with all the mechanical appliances which facilitate the transfer of merchandise and passengers from rail to water and from water to rail without delays or confusion.

RULE APPLIED TO SAN FRANCISCO.

Resources of Hinterland.

With its magnificent extent of 158,000 square miles of territory, the State of California, together with the neighboring States to the eastward, offers in its multitude of resources a rich back country for a great port. California has wide and fertile valleys, enjoying a climate that is nearly perfection, grand lakes, and mountains abounding in timber and mineral wealth, while two navigable rivers converge in the Bay of San Francisco.

Rich in agricultural and manufacturing possibilities, California is yet in the merest preliminary stages of its development, and the potential commerce that it promises far outreaches the volume of its present trade. With a population of 1,700,000 its soil is capable of supporting upwards of 30,000,000 of people, and yielding a commensurate increase of commerce which shall pass through its ports to the marts of the world. The semi-arid regions of adjacent States, now but sparsely settled, are susceptible of great development, partly through irrigation, and probably to a much greater extent by the cultivation of appropriate plants, and through improved methods of farming, and also from the development of the mineral resources.

Ocean and Rail Routes.

This city is located on a magnificent bay which is by far the finest and most commodious harbor on the Pacific Coast. It has an entrance nearly a mile in width and of ample depth, through which the commerce of the world can pass into a bay whose waters cover an area of about 257 square miles, of which 79 square miles has depths from 18 feet to 60 feet at low tide, and all of which affords excellent anchorage ground.

The largest ocean in the world—the highway to China, Japan, the Philippines, Australia, New Zealand and the South Pacific Islands, bordered by a population which runs into the hundreds of millions of people who will trade with the United States through Pacific Coast ports, is at its door.

The completion of the Panama Canal will undoubtedly add to the volume of the commerce of this port, and it is not unlikely that immigrants for the Western States coming from European ports will be landed directly at San Francisco, as immigrants for the Southern States are now taken by direct ocean lines to Galveston.

Not only do the lines of ocean commerce focus at the entrance of the harbor of San Francisco; but, on the landward side, transcontinental railways lead the trade of the Eastern States to our wharves, and still other roads are directing their energies to make San Francisco their Pacific terminus.

To retain and encourage this commerce it is necessary for the State to build, slightly in advance of actual needs, substantial wharves at reasonable cost of construction and maintenance, and to keep port charges down to a minimum rate, sufficient only to produce a revenue for operation, repair, maintenance and new construction, and thus make this one of the cheapest, most commodious and desirable ports in the world.

To carry such a determination successfully into effect it is necessary that each separate addition to the harbor facilities should be itself a component part of a general plan of port development, which shall intelligently anticipate and gradually provide for the commerce of the future.

Illustrated by Foreign Ports.

That it is a wise business policy to develop a port in anticipation of its actual present necessities, is evident from a study of the application of the principle abroad.

The large ports of Europe have followed the practice of inviting trade by providing for the ample accommodation of a commerce somewhat in advance of immediate necessity, and their reward has been a vastly increased trade with a corresponding gain in population. This is particularly true at Hamburg, Antwerp, Rotterdam and Liverpool. A reference to the Statistical Chart will show that the time at which such improvements were made was succeeded by a period during which the gain in the commerce of that port was notably accelerated. This particularly true of Antwerp and Liverpool since 1900, and a comparison of these two ports with the conditions at London, where the port facilities have not recently been developed beyond the actual requirements of its existing commerce, shows in a graphic manner the result of a wise extension of dock area.

Wealth and power attend commercial increase, and the history of European ports proves that commerce responds with an accelerated rate of gain to favorable conditions provided for shipping.

Business tends to crystallize, and trade once attracted to a port by reason of superior facilities and benefits is not readily deflected to other routes. Habits of trade are formed and merchants become acquainted and continue to do business at the same center, largely from the force of associations which once made are not easily severed. Favorable conditions give rise to successive improvements, such as betterment of railway, postal and telegraph service. More banks are established and new lines of railroad projected. These in turn result in new additions to the volume of the port's commerce, which increases somewhat similar to compound interest. These gains are attended by more orderly conditions of civic life. Merchants enlarge their stocks, and trade is attracted from a wider radius.

Thus the law of port development, as applied in Europe, has resulted in the enormous prestige of the ports which have adopted its principle. Liverpool, Hamburg, Rotterdam, Bremen, Havre, Amsterdam, Marseilles and Genoa may be all instanced as ports that have been built up under difficulties and at great cost of money. Each is prosperous to a high degree, and enjoying a commerce beside which the trade of undeveloped ports is insignificant. Each as a matter of sound business policy is anticipating still larger demands of increasing trade and carefully preparing plans for further port development.

While there are thus few ports of the first rank, it is also true that even these may become stationary or decadent through bad management, or the failure to carry out the policy of anticipating trade needs by adequate extensions. The famous London docks have nearly reached the limit of their ability to accommodate the trade of the metropolis. This is due in part to the rapid increase in size of ships which makes it difficult for the vessels of heavier tonnage and greater length to enter, and also to the failure to provide more docks. Both of these defects at London may be remedied and plans have recently been prepared for this purpose. Yet the temporary abandonment of the policy of anticipation has resulted in a slackening of the rate of gain of London's commerce, while at Liverpool where large extensions have been made in recent years a corresponding increase in trade is manifest. London, with 6,000,000 population, has an annual commerce of 17,600,000 tons; while Liverpool, with one-ninth the population of London, has a commerce of over 16,000,000 tons.

By reason of these experiences public sentiment in Europe favors the highest development of the great ports and the spending of comparatively moderate sums on ports of the second and third classes; chiefly for the reason that the latter have already been distanced, and would not yield sufficient interest on the expenditure necessary to make them ports of the first rank; but also because the crystallization of trade at the larger ports has acted as a deterrent influence upon the minor centers of seaboard trade.

PART II.

CONDITIONS AT SAN FRANCISCO.

DESCRIPTION OF HARBOR.

Having outlined the general law of port development, we will now consider the conditions at San Francisco somewhat in detail before passing on to a study of the requirements of the port, a forecast of its future commerce, and the problem of the extension and betterment of its docks.

Entrance to the Harbor.

The Golden Gate is the entrance which connects the Bay of San Francisco and its rivers with the Pacific Ocean. It is about three miles in length, nearly a mile wide in its narrowest part, and has a maximum depth of 360 feet. Its shores are high, bold and rocky. Outside the entrance, and about six miles distant, is the "Bar," on which there is a least depth of 33 feet at low tide. There is also another channel of approach to the entrance to the harbor, known as the North or Bonita Channel, which is one-third of a mile in width, and which has a depth of 54 feet.

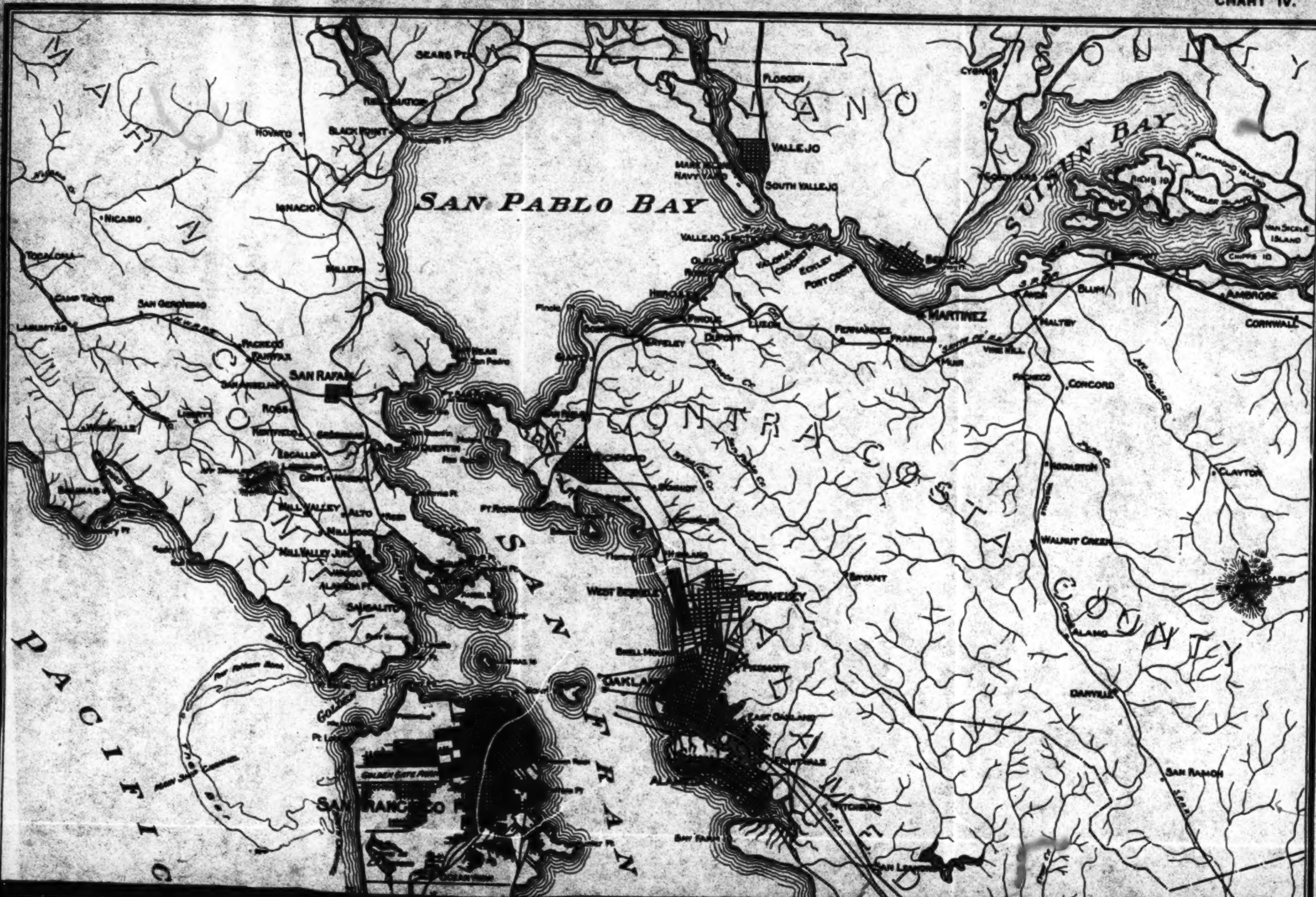
No matter how great the draft of the ship of the future, it will always be able to enter this port in safety.

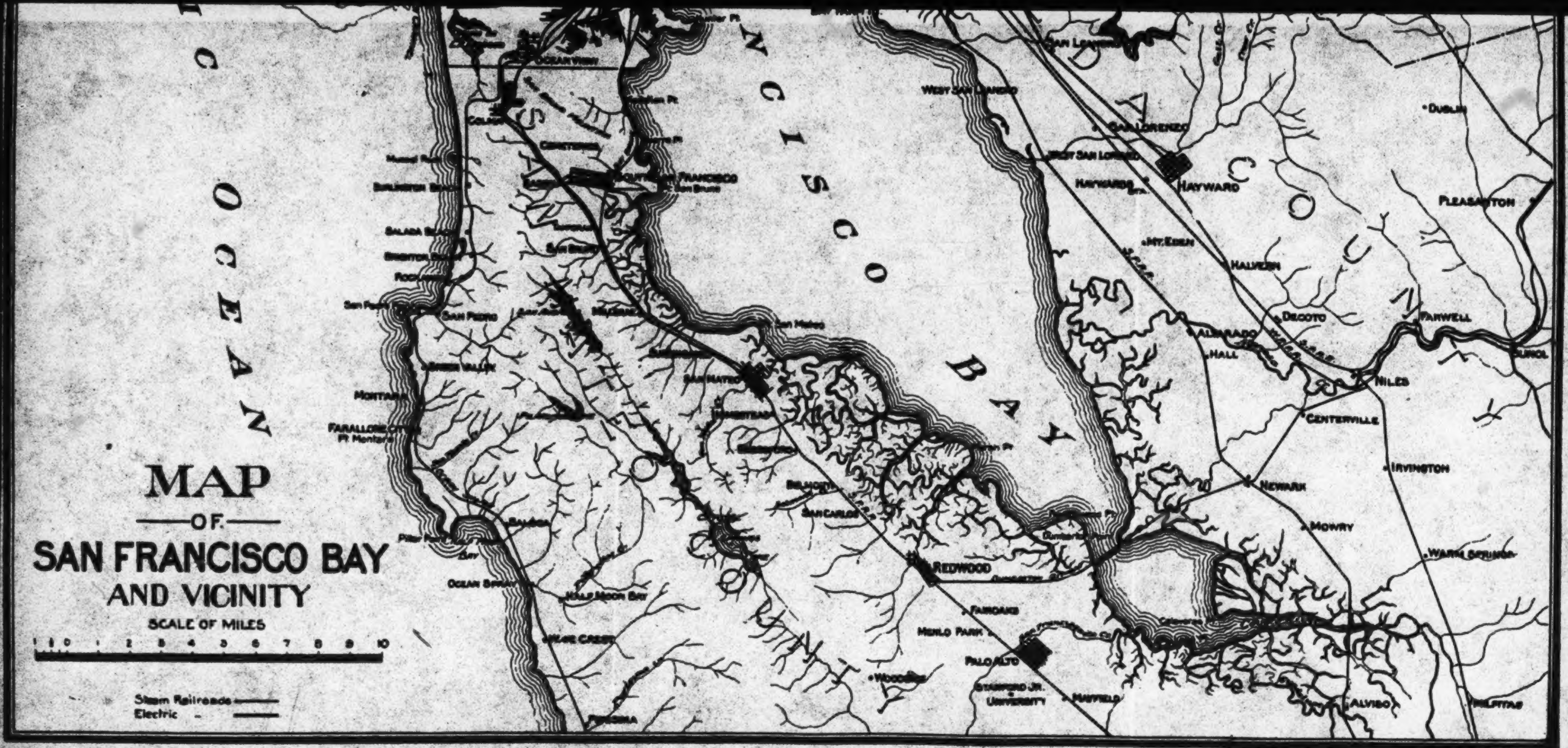
Extent of Shore Line.

At San Francisco Nature has supplied a deep, safe, commodious waterway, open to the commerce of the world. San Francisco with San Pablo Bay, its northern extension, covers an area of 420 square miles. The shore line of San Francisco Bay alone, leaving out of consideration for the time its numerous navigable inlets, measures 100 miles in length. From the southern portal of the Golden Gate at Fort Point, along the bay shore of San Francisco and San Mateo counties to Dumbarton Point, thence across the narrows and along the shores of Alameda, Contra Costa and Marin counties to Lime Point, every mile is suitable and available for commercial and industrial use.

The City of San Francisco, situated on the peninsula on the

CHART IV.


SAN PABLO BAY
SUISUN BAY
SOLANO COUNTY
MARIN COUNTY
CONTRA COSTA COUNTY
ALAMEDA
SAN FRANCISCO BAY
PACIFIC
Sears Pt.
Reclamation
Novato
Black Point
Ignacio
Nicasio
Tocaloma
Camp Taylor
San Geronimo
Lagunitas
Pacheco
Fairfax
San Rafael
San Anselmo
Ross
Kentfield
Mill Valley
Alto
Mill Valley Jct.
Sausalito
Vallejo
South Vallejo
Mare Island Navy Yard
Flosden
Cygnus
Benicia
Martinez
Port Costa
Eckley
Crockett
Vallejo Jct.
Hercules
Pinole
Sobrante
Giant
Rodeo
Selby
Tormey
Valona
Oleum
Avon
Bay Point
Ambrose
Cornwall
Maltby
Vine Hill
Muir
Franklin
Fernandez
Christie
Glen Frazer
Concord
Pacheco
Walnut Creek
Clayton
Mt. Diablo
Alamo
Danville
San Ramon
Bryant
Richmond
Pt. Richmond
Stege
Berkeley
West Berkeley
Oakland
Piedmont
East Oakland
Fruitvale
Alameda
Golden Gate
Golden Gate Park
San Francisco
San Leandro
Ryde Island
Chipps Id.
Van Sickle Island
Point San Pedro
San Quentin
Point Reyes



MAP
OF
SAN FRANCISCO BAY AND VICINITY

SCALE OF MILES
1 0 1 2 3 4 5 6 7 8 9 10
Steam Railroads
Electric
OCEAN
SAN FRANCISCO BAY
SAN MATEO
ALAMEDA COUNTY
Ocean View
Colma
Cemeteries
South San Francisco
San Bruno
Mussel Rock
Burlington Beach
Salada Beach
Brighton Beach
Rockaway
San Pedro Pt
San Pedro
San Andreas
Millbrae
Montara
Farallone City
Pt Montara
Pillar Point
Half Moon Bay
Ocean Shore
Purisima Creek
Pescadero
Burlingame
San Mateo
Belmont
San Carlos
Redwood
Fair Oaks
Menlo Park
Palo Alto
Woodside
Stanford Jr. University
Mayfield
San Leandro
West San Leandro
San Lorenzo
West San Lorenzo
Haywards Sta.
Hayward
Mt. Eden
Halvern
Decoto
Alvarado
Hall
Niles
Centerville
Farwell
Sunol
Dublin
Pleasanton
Irvington
Newark
Mowry
Warm Springs
Alviso
Milpitas

south side of the entrance of the bay, has within its city and county limits a water frontage on the bay from the Presidio to the boundary line of San Mateo county about ten miles in length. If the measurements be made along the shore line to include the channels and basins, viz., South Basin, India Basin, Islais Creek, Central Basin and Channel street, the water front has an aggregate length of thirteen miles.

NATURAL ADVANTAGES.

The natural advantages of San Francisco Harbor are obvious. We do not require expensive masonry basins or docks, in which a fixed level of water is maintained by means of machinery and gates, and which only permit of ingress and egress at about the time of high water. Such inland docks are generally necessary at most of the large commercial ports in Europe either because of excessive range of tides there—in some cases amounting to 30 or more feet—or by reason of a situation on comparatively narrow rivers, or from both causes. The following table gives the tidal range and width of rivers at various European ports compared with San Francisco where the average height of the tide is but 4.3 feet and the bay four miles in width:

London	Width of	Thames......	1400 ft.	Tidal Range..	24 ft.
Liverpool	“ “	Mersey......	5000 “	“ “	33 “
Antwerp	“ “	Scheldt......	1500 “	“ “	25 “
Hamburg	“ “	Elbe.........	1000 “	“ “	17 “
Bremerhaven	“ “	Weser.......	2300 “	“ “	10 “
Bremen	“ “	“	400 “	“ “	23 “
Rotterdam	“ “	Meuse.......	1000 “	“ “	
Havre	“ “	Seine........	“	“ “	25 “
San Francisco.......	“ “	S. F. Bay..	4 mi.	“ “	4.3 “

All of the above European ports now possess excellent accommodation for ships, but it has only been accomplished by the expenditure of vast sums of money which, at Liverpool, has reached about $200,000 per acre of enclosed basin, and all of the ports are still engaged in extension of their improvements.* Cessation of this work would mean loss of trade, or, perhaps, commercial death.

GOVERNMENT IMPROVEMENTS.

The improvements made by the United States Government to the Bay of San Francisco in the interests of navigation and commerce consisted in the removal from the harbor of obstructions known as Blossom Rock, Shag Rock, Arch Rock and Rincon Rock, and the establishment of lights and fog signals at entrance of and inside the harbor. The entrance to the harbor is thoroughly protected by fortifications of the most improved modern type. Surveys for estimating the cost of removal of two rocks known as Centissima and Sears Rock, on the east side of Bonita Channel, and also of two small rocks inside the harbor near Mission Rock and known as Mission Bay Rock and Sonoma Rock, respectively, are in progress.

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*See pages 20-21.

ADJACENT WATERS.

San Pablo Bay, which is a continuation of this harbor to the north, is fourteen miles in length by about twelve miles in width. It is connected by Carquinez Straits with Suisun Bay, which is ten miles long and from five to six miles wide. Into the head of this bay empty the two largest rivers in the State, the Sacramento and the San Joaquin.

Through San Pablo Bay there is a navigable channel which is kept at an approximate depth of thirty feet for its entire length to Carquinez Straits. Through the Straits at Carquinez the channel is more than half a mile in its least width, and has a depth of from eight to ten fathoms. In Suisun Bay the channel has a least navigable depth of thirteen feet at low tide.

The Sacramento River is navigable throughout the year for 262 miles of its length to Red Bluff . The San Joaquin is always navigable to Stockton about forty miles above its mouth and occasionally to Firebaugh's, more than 100 miles further up the river. These two rivers drain the great central valleys of the State and carry annually a commerce exceeding a million tons. While the population of these valleys is small, the lands are as fertile and as productive as any in the world and capable of furnishing homes for several million people.

Emptying into each of the bays above referred to are smaller navigable rivers, sloughs and creeks, which together float a commerce of very nearly another million tons per year. On or near the shores of San Francisco Bay, besides Oakland, Berkeley and Alameda are the flourishing towns of South San Francisco, San Mateo, Redwood, Palo Alto, Newark, Alvarado, Haywards, San Lorenzo, San Leandro, Fruitvale, Piedmont, Richmond, San Rafael, Tiburon, Belvedere and Sausalito. On or near San Pablo Bay are San Pablo, Giant, Sobrante, Pinole, Rodeo, Vallejo and the Mare Island Navy Yard; while on the Straits of Carquinez are Crockett, Eckley, Port Costa, Martinez and Benicia.

FEDERAL HARBOR LINES.

The area in which wharves may be built on the San Francisco water front is limited in length by that of the shore line on the bay, in the county (about ten miles); and in width by the distance between the established harbor lines, known respectively as the bulkhead or seawall line and the pierhead line. These lines were recommended by State boards or commissioners and received final approval by the Secretary of War.

The bulkhead line is one to which solid filling from the shore is permitted, and on which about two miles of seawall has been constructed, and along which future extensions of the same may be built. Its general location is in water from 10 to 24 feet in depth.

Between the bulkhead line and high water or shore line, there was originally about 2500 acres (four square miles) of submerged land, all of which was divided into city blocks and streets and sold more than thirty years ago by the State of California through its Commissioners for the sale of Salt Marsh Tide and Submerged Land. Approximately 900 acres of this submerged area, generally north of the Union Iron Works, has been reclaimed (filled in) and is now some of the most valuable real estate in the city. Of the other 1600 acres, most of which lies south of the sugar refinery in the vicinity of Islais Creek, India Basin, Hunters Point and South Basin, little or no reclamation work has as yet been attempted. This submerged area might have been very useful for building wharves in inclosed basins, but having been disposed of by the State it is now held at such a high valuation as to make it almost prohibitive for the State to acquire for harbor purposes.

The pier head line, or that which limits the length to which wharves may be built, is reasonably parallel to and from 200 to 800 feet outside the bulkhead line.

WHARVES AND COMMERCE.

At present there are on the water front thirty-one wharves averaging about 600 feet in length by 93 feet in average width, and having slips alongside which average 161 feet in width. Our best wharves, however, have widths of 140 feet with slips 220 feet wide. The axis of the wharf is perpendicular to the seawall or bulkhead, hence such a wharf of an average length of 600 feet by a width of 93 feet, and its adjacent slips of 161 feet average width occupies 254 feet in length of water front and furnishes 1200 feet of berth room on the two sides of the wharf, or practically one foot in length of water front by the use of wharves, furnishes at present about 4.7 feet in length of berth room. About 1.8 miles of San Francisco water front is now occupied by wharves which furnish berthing facilities 8.3 miles in length.

PUBLIC CONTROL OF DOCKS.

At San Francisco all the wharves are public and under the sole control of the Board of State Harbor Commissioners, which consists of three members. The Commissioners are appointed by the Governor and hold office for four years. The Governor and the Mayor of San Francisco are ex-officio members of the Board for certain specified purposes. The Board, by authority of the State Legislature, fixes rates for dockage and wharfage, locates and builds wharves where deemed best, and makes repairs and maintains all wharves, piers, quays, landings and thoroughfares along the water front that the commerce requires. It also makes rules and regulations concerning the property entrusted to it; designating anchorages in the harbor, and maintaining unobstructed fairways in the same. It determines the time merchandise landed at any wharf shall remain on the dock without extra charge, and assigns certain spaces for specific uses. It extends and repairs the street along the city's water front to a maximum width of 150 feet, and extends sewers upon the outer half. It may build seawalls; lay tracks for and operate a Belt Railroad, and condemn land for certain specific purposes. Where new wharves or bulkheads are constructed it may lease them for a period not to exceed 15 years for an amount not to exceed the cost of such construction. New wharves have recently been constructed under the plan of asking bids from steamship companies in terms of least number of years free rental in return to the company for bearing the whole cost of construction of the pier it desires for its own use.

Public ownership of docks is certainly advantageous to the port and to the shipping interests. Concerning this matter, the State Board of Massachusetts on docks and terminal facilities, after a long and thorough examination of domestic and foreign ports in 1897, said in part:

"It should afford accommodation at the lowest rate of charges; private individuals cannot be expected to furnish these for such returns on the investment as they would accept; the uncertainty of immediate returns is against large outlay by private individuals; private interests not the public welfare is naturally and properly their first thought, and the making of a port a great commercial center is a secondary consideration. Public welfare demands the largest volume of trade at least cost, low uniform and stable charges, first-class equipment, ample accommodation and abundant facilities at the lowest charge to the user; that cheaper money can be had if required by using the credit of the State than that of individuals; that the charges to the user be enough to pay a low rate of interest on the cost, annual disbursements for maintenance, repairs and a sinking fund sufficient to reimburse original outlay say in seventy-five years."

The ownership and control of docks and wharves in some of the more important seaports of the United States is as follows:

New York............	Public—	Railroad and	Private
Baltimore	"	"	"
Norfolk	"	"	"
New Orleans..........	"	"	"
Boston		"	"
Philadelphia		"	"
Newport News		"	"
Savannah		"	"
Charleston		"	"
Galveston		"	"
San Francisco	Public		

REVENUES OF THE PORT.

The water front of San Francisco is self-sustaining. That is, it produces a revenue which pays the expenses, and no tribute in the way of public taxation has ever yet been levied or required from city or State.

The revenue derived from dockage, tolls, rents, leases, wharfage, etc., pays all the expenses of construction, operation and maintenance. While bonds to the amount of $2,600,000 have been authorized to be sold for a ferry building, and for certain other work on the water front, only a small portion have been offered for sale and disposed of. The interest and sinking fund for such as have been sold is met from the revenues of the port.

Since 1863, when the State Harbor Commission took charge of the harbor, the total receipts or revenue from all sources, up to June 30, 1907, amounted to $23,163,059. The disbursements have been substantially the same.

The port charges for dockage tolls and wharfage in the last ten years have varied from 11.2 cents to 15.7 cents per ton; amounts which compare favorably with charges for the same service at other ports. The port revenue in seventeen European ports (see page 20) in 1906 was 40.6 cents per long ton of cargo.

LOADING AND UNLOADING.

The rapidity with which a vessel loads and discharges her cargo is one of the factors which determines the profit of the voyage for the shipowner. This is especially true where the charge for dockage is on a per diem rate. Its advantage to the dockowner is also considerable, as a greater number of vessels can be accommodated within a given time, and a greater revenue derived from toll charges on merchandise reckoned by the ton. Efficiency of the labor employed in stevedoring and the convenient arrangement of the docks determine the rapidity with which cargo may be handled.

Records have recently been established at San Francisco which compare favorably with those of European ports. China steamers have frequently discharged 6000 and loaded 10,000 tons in ten days, or at a rate of 1,600 tons a day of eight working hours, that is, two hundred tons per hour.

The report of the Royal Commission of the Port of London, 1902, contains a record of observation of 58 vessels discharging a total of 244,764 tons in 3908 working hours, or 62.6 tons per working hour; and the report states that the minimum and maximum rates were respectively 50 and 176 tons. At Montreal eight of the same vessels discharged at a rate of 52.2 tons per hour; while eight discharged at New Orleans at a rate of 44.7 tons per hour.

The average rate of discharging cargo at San Francisco was not obtainable, but from recent records of single steamships it would seem to be greater than in foreign ports.

The "Korea," which arrived at San Francisco on February 14, 1908, commenced discharging 6319 tons of cargo at 12:30 P. M. on that date, and completed on the 18th at 1 P. M., within 28 working hours, or at a rate of 225.7 tons per working hour.

PORT CHARGES COMPARED.

Wharf charges and tolls including stevedoring and pilotage at San Francisco Harbor average about 58.4c per ton.

The actual tolls for dockage are considerably less than at foreign ports, but the higher wages paid to stevedores bring the average of all port charges somewhat above that of foreign ports, which may be taken as approximately 53c per ton.

The following tables are compiled from the report of the London Commission in 1902 and the comparison is made with charges at San Francisco for similar cargoes of approximately five parts grain, three of general merchandise and two of lumber.

PORT CHARGES AT SAN FRANCISCO

COMPARED WITH

SIX EUROPEAN PORTS.

Compiled from the report of the Royal Commission, London, 1902. For a cargo steamer of 3388 tons gross, 2202 tons net, laden with 2000 tons grain, 1500 tons general merchandise and 666 M (1000 tons) Lumber; discharging:

PORT CHARGES

	Liverpool	Hamburg	Rotterdam	Antwerp	Bremerhaven	London
Days	3	7	5	6	4	6
Harbor and River Dues......	$	$	$146.10	$	$	$ 38.25
Dock and Quay Dues........	713.59	893.75		267.85	530.83	612.85
Pilotage..........................	55.73	78.55	146.10	175.32	82.82	111.52
Tug Hire	41.41	53.57	24.35	24.35	43.83	48.75
Boatmen	29.23	9.74	4.87	17.05	9.74	19.48
Totals	$839.96	$1035.61	$321.42	$484.57	$667.22	$ 830.85
Stevedoring	$669.92	$ 686.82	$487.00	$558.04	$643.00	$ 937.00
Overtime.........................	204.54	116.98	73.10	24.35	87.75	167.12
Tallying..........................		95.50	170.45	102.38	146.25	230.25
Crane Hire				97.50		121.41
Totals	$874.46	$ 899.30	$730.55	$782.27	$877.00	$1455.78
Average Port Charges......... Per Net Ton............	.381	.47	.146	.22	.303	.38
Average Cost Stevedoring..... Per Actual Ton	.195	.20	.16	.174	.195	.323
Average Total Charges.......	.576	.67	.306	.394	.498	.703

SAN FRANCISCO

Dockage, 10 days @ $19...............	$190.00
Tolls, 3500 tons mdse. and grain......	175.00
Tolls, 666 M lumber......................	66.60
	$431.60

Average per ton........$ .196
Add for pilotage....... .047
$ .243

Stevedoring 3500 tons @ 45c...	$1575.00
Stevedoring 666 M lumber @ 30c...	199.80
	$1774.80

Average per ton.........$ .3944

Stevedoring,

2000 tons grain @ 35c...............	$ 700.00
1500 " Mdse. @ 40c...............	600.00
666 M lumber @ 50c...............	333.00
4500 tons.	$1633.00

= .243c.
0.334c. per ton.
57.7 cents.

COMPARISON OF PORT CHARGES

	Port Dues	Stevedoring	All Charges
Average Six European Ports...........	$ .3167	.2078	.5245
Average at San Francisco...	.2430	.3944	.6374

PORT CHARGES AT SAN FRANCISCO
COMPARED WITH
SIX EUROPEAN PORTS.

Compiled from the report of the Royal Commission, London, 1902. For a cargo steamer of 9040 tons gross, 5146 tons net, laden with 5000 tons grain, 3000 tons general merchandise and 1333 M Lumber (2000 tons); discharging:

PORT CHARGES

	Liverpool	Hamburg	Rotterdam	Antwerp	Bremerhaven	London
Days	3	14	14	14	14	14
Harbor and River Dues	$	$	$389.60	$	$	$ 78.34
Dock and Quay Dues	1674.66	1799.76		730.80	1509.70	1253.56
Pilotage	120.60	117.30	219.15	277.59	83.94	147.54
Tug Hire	116.90	76.43	43.83	77.92	78.39	290.00
Boatmen	53.57	9.47	7.30	24.35	16.56	24.35
Totals	$1965.73	$2002.96	$659.88	$1110.66	$1688.59	$1793.79
Stevedoring	$1908.12	$1695.27	$1071.40	$1187.55	$1339.80	$1826.50
Overtime	633.10	243.50	146.10	243.50	243.50	641.78
Tallying		214.28	292.20	292.20	292.20	275.00
Crane Hire				243.50		145.50
Totals	$2541.22	$2153.05	$1509.70	$1966.75	$1875.50	$2888.78
Average Port Charges Per Net Ton	.38	.389	.127	.215	.327	.348
Average Cost Stevedoring Per Actual Ton	.28	.238	.167	.217	.209	.318
Average Total Charges	.66	.626	.294	.432	.536	.667

SAN FRANCISCO

16 days @ $41.19	$659.04		
Tolls, 8000 Tons Mdse. and Grain	400.00		
Tolls, 1333 M lumber	133.30		
Total	$1192.34	Average Per Ton	$ .231
Stevedoring 8000 Tons @ 45c	$3200.00		
Stevedoring 1333 M Lumber @ 45c	599.85		
Pilotage (if Foreign)	132.00		
Total	$3,931.85	Average Per Ton	$ .393
5000 tons grain @ 35c	$1750.00		
3000 tons Mdse. @ 40c	1200.00		
1333 M lumber @ 50c	666.66		
10000 tons	$3616.66	=	36.17c per ton
		Port Charges	23.1
		Total	$ 0.592

COMPARISON OF CHARGES

	Port Dues	Stevedoring	All Charges
Average Six European Ports	$ .297	$ .239	$ .536
Average at San Francisco	.231	.393	.624

PILOT CHARGES.

The pilot rates at San Francisco are $3 per foot draught for vessels from foreign ports under 500 tons register. Over 500 tons the rates are $3 per foot draught, and 3 cents per ton registered tonnage. The inward and outward rates of pilotage are the same

The San Francisco pilots admit that their rates are somewhat higher than those in other United States ports. This is probably due to the charge of 3 cents per ton on the registered tonnage, in addition to the rate charged on the draught of the vessel.

The actual amounts received for pilotage here could not be ascertained. The pilots pay 5% of gross receipts to the Board of Pilot Commissioners—the Commission appoints the pilots—the Governor of the State appoints the Commissioners, and the latter publish no reports available to the public.

At most American ports the legal rate of charge for pilotage is based on the actual draught of the vessel when entering or leaving port. The rates at New York are as follows:

	Inward (per ft.)	*Outward*
For vessels up to 14 feet draught	$2.87	$2.02
" " 14 to 18 feet "	3.28	2.33
" " 18 to 21 feet "	4.13	3.08
" " more than 21 ft. "	4.88	3.56

At Philadelphia the following rates are in effect:

For vessels 12 feet draught and under	$4.40	$4.00
" " over 12 feet draught........	5.50	5.00

VOLUME OF COMMERCE.

The total amount of commerce at San Francisco Bay for the year ending June 30, 1907, was 9,678,336 tons.

One million tons of this was the amount of trade for the year between San Francisco and river points. The remainer, or 8,768,336 tons, was the volume of the coastwise and foreign commerce entering and sailing from San Francisco Bay.

Of this last amount 1,541,000 was accommodated at the wharves of the Oakland estuary; while approximately 1,500,000 tons was divided between Port Costa, Point Richmond, Selby's and the Oakland long wharf; and 6,802,792 tons was handled over the water front of the city of San Francisco.

The figures for the total tonnage of San Francisco Bay are taken from the report of the Merchants' Exchange, this data being compiled from observation made at the Merchants' Exchange Station on Meiggs Wharf of all vessels, steam and sail, for or from coastwise and foreign ports, bound inward and outward through the Heads. The total amount of the tonnage handled over the San Francisco wharves is taken from the report of the Harbor Commissioners.

The annual tonnage by water of San Francisco, has increased from 739,190 tons in 1863, to 6,802,192 tons in 1907, a rate of growth which is equal to over five per cent. compound interest. In the last twenty years the volume of commerce of the port has more than doubled, until the value of exports and imports recorded at the Custom House amounts to over $100,000,000 annually, exclusive of shipments of treasure.

The principal exports cleared at San Francisco are flour, cereals, wines and brandies, fruit, crude oil and whale oil, salmon, wool, mineral products, and manufactures of Eastern States.

The principal imports are rice, tea, coffee, Oriental goods, lumber, cement, coal, manufactured goods and tropical fruit.

The Harbor Commission report that: "During the year ending December 31, 1907, there were docked at the port of San Francisco 6900 steam vessels, with a total tonnage of 3,895,454. Of this number 2937 were bay and river craft; and the balance, or 3963, were deep sea going vessels. This does not include the ferry boats, which make 170 trips daily and carry 100,000 passengers.

"During the same period there were docked at this port 748 sail vessels with a total tonnage of 720,149. Of this number 729 were deep sea going vessels and 19 were bay and river craft of over 90 tons registered measurement."

Expressed in tabular form the above shows:

Total number of vessels docked in 1907		7.648
Deep sea going	4,692	
Bay and river craft	2,956	
Steam	6,900	
Sail	748	

In the biennial report of the Commission for the two years ending June 30 1904, it is stated:

"The remarkable activity in shipping to and from this port during the last two years foreshadows the possibilities of our commercial trade in the future. Never in the history of San Francisco has the volume of shipping trade been so large as during the period that this report embraces."

The report cites the fact that several years ago vessels discharged on the wharf from 100 to 300 tons of freight per day, while more recently vessels have discharged as much as 750 tons in one day and congested the docks because the consignees failed to remove the cargo as fast as the ships unloaded.

Table showing the coastwise and foreign commerce at San Francisco for the year ending June 30, 1907. From the annual report of the Merchants' Exchange, 1906-07:

	Inward (tons)	*Outward*
Domestic—		
Coast	2,744,776	2,994,364
Hawaiian Islands	198,931	187,946
Alaska	58,241	45,137
Philippines	56,754	62,704
Foreign—		
China and Japan	326,298	273,998
Siberia and India	19,923	24,792
European ports	274,724	161,397
Other Pacific ports	669,001	569,350
Totals	4,358,648	4,319,688
Grand Total, '07		8,678,336
'06		7,320,926
'04		6,447,664
'02		6,256,066

COMPARISON WITH OTHER PORTS.

Greater New York, by far the largest commercial port in America, has a population a little in excess of 4,000,000. The reports concerning the domestic water borne commerce of New York are so much at variance that they cannot be reconciled. Its foreign commerce for 1907 is reported to have been 20,458,526 tons and was valued at $1,400,000,000. New York claims a water front of a total length of 445 miles, of which only 25.21 miles (the productive unit) is owned by the city and under the control of the Department of Docks.. The best piers of very recent construction, known as the Chelsea-Gansevoort section, are in the North River and consist of twelve piers which are generally 825 feet long, 125 feet wide and with slips adjacent 250 feet in width. The docks contemplated at South Brooklyn are to be about 1,300 feet in length, 150 feet in width, with slips from 200 to 270 feet in width.

London has a population of 6,580,000 and an existing commerce of 17,600,000 tons, dock room and basins of 640 acres and a total length of berthway, including that of the wharves in the Thames, of 42 miles.

Liverpool has a population of 700,000, a basin and dock area of 582 acres, berth room of 35 miles and an annual commerce a little in excess of 16,000,000 tons.

AVERAGED DATA CONCERNING FOREIGN PORTS COMPILED FROM PROCEEDINGS OF PERMANENT INTERNATIONAL NAVIGATION CONGRESSES—RESULTS OF INVESTIGATION INTO COST OF PORTS AND THEIR OPERATION, BY

ELMER L. CORTHELL, C. E.,

Brussels, 1907.

The ports are London, Liverpool and Birkenhead, Glasgow, Bristol, Hamburg, Rotterdam, Le Havre, Dunkirk, Bilbao, Antwerp, Bremen and Bremerhaven, The Tyne Ports, Marseilles, Amsterdam, Lisbon, Bombay and Buenos Ayres.

Total cost of port improvements to 1906	$764,388,000
Registered tonnage, entered and cleared in one year (about '05-'06)	185,652,000
Goods dealt with in long tons of 2240 lbs., approx.	143,000,000
Gross revenue in one year (about 1905-06)	$ 58,206,000
Expenses in one year (about 1905-06)	29,003,000
Net revenue in one year (about 1905-06)	29,203,000
Gross revenue per registered ton (about 1905-06)	31.4 cents
Gross revenue per long ton (about 1905-06)	40.6 cents
Quayage, length in feet	1,192,000
Quayage, length in miles	227
Length of rail, approx., in miles	930
Length of rail, divided by length of quayage	4.11
Area of sheds, to quayage 44,467,770 sq. ft. of sheds to 1,067,120 lineal feet of quay—ratio	41.1 to 1
Average goods dealt with per year per lineal foot of quay (long tons)	120
Per cent. of gross income on capital cost	7.615%

One crane to 283 feet of quay.

COST OF 15 FOREIGN PORTS, TO 1905-06

As Reported by

ELMER L. CORTHELL.

Proceedings of Permanent International Navigation Congresses, Brussels, 1907.

London	$172,000,000
Liverpool and Birkenhead	142,000,000
Glasgow	41,000,000
Bristol	24,000,000
Hamburg	72,000,000
Rotterdam*	10,394,000 (in last 25 yrs.)
Le Havre	39,349,000
Dunkirk	20,710,000
Antwerp	44,000,000
Bremen and Bremerhaven	38,156,000
The Tyne Ports	31,302,000
Buenos Ayres	35,551,000
Bombay	21,500,000
Marseilles	28,708,000
Amsterdam	35,926,000

The total expenditures of the New York Department of Docks, from its organization in 1870 to Dec. 31, 1906, was $81,595,246, of which $23,392,000 had been used for the purchase and acquisition of property.

PART III.

REQUIREMENTS AND FORECAST.

COST NOT BURDENSOME.

The requirements of the port of San Francisco are not excessive, nor need the undertaking to make this a first rank port be burdensome. The foregoing inquiry has shown that in some particulars we have already advantages which other ports must struggle to obtain. Public ownership has been established, and not only are the docks and harbor frontage in the control of a State Commission, but a Belt Railroad on the water front is now in successful operation under State ownership and only requires extension to perfect its service. These two elements of development are fundamental, and they are yet to be obtained in many less fortunate ports.

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*Later information makes Rotterdam cost $20,000,000.

Added to this is the favorable tidal range of less than five feet, which does not necessitate the construction of expensive masonry docks and basins inclosed by solid walls, which must be entered through gates only opened at high water.

Hence it follows that we have the proper governmental machinery for extension and development, and that this extension will not be attended by excessive cost, the necessity of large bond issues and the deterrent factor of debt.

We may safely assert that for one-fourth the expenditure which has been incurred, for instance, at Liverpool, the harbor facilities at San Francisco might be extended to accommodate a commerce of twice the volume of that which enters and clears at Liverpool, and furnish more convenient berth room and more commodious facilities for the expeditious handling of freight.

Briefly, then, the requirements of this port are more docks, more warehouse space on the harbor front, and an extension of the present Belt Railroad. A wise business policy dictates the formulation of a comprehensive plan of sufficient scope to provide for probable future growth of the commerce of this port, and the anticipation of the needs of that commerce by gradual building of additional wharves along the lines of that predetermined plan.

RELIEF OF CONGESTION.

At the present time only 1.8 miles of the water front have been developed by the construction of docks, out of the total extent of ten miles. The present docks furnish 8.3 miles of berthing room, and as each foot of water front gives 4.7 feet of berth room, it follows that the development of the entire ten miles would furnish 47 miles of berth room.

During the year ending June 30, 1907, there was laden and discharged at the 8.3 miles of berth room of the San Francisco docks freight amounting to approximately 7,000,000 tons, or in round numbers 843,000 tons to the mile of berth room.

In 19 foreign ports (see table on page 20) there was handled in 1906 a grand total of 185,652,000 tons of merchandise over 227 miles of quayage, or an average of 630,000 long tons to the mile. From the number of factors in this result it may be presumed to represent the normal capacity of one mile of berth room abroad. It follows that in San Francisco at the present time there is being handled on the docks cargoes which are 35 per cent in excess of those handled abroad per mile of berth room, which indicates that our docks should be extended in a somewhat similar proportion.

However moderate the port charges may be, under certain conditions shipowners may assert it to be an expensive place to handle their cargoes, and the resulting congestion may be a deterrent to the increase of the trade of the port. The wise business policy of port development, as outlined in the first section of this report, is not only to provide ample accommodation for the present commerce, but to anticipate the needs of trade by building slightly in advance of present necessity.

In a recent report the Harbor Commissioners say that the greatest difficulty with which they have to contend is to induce consignees to remove freight from the wharves in a reasonable time after it is landed; and that even if the number of docks were to be increased fifty per cent. they apprehend the same difficulty would remain.

Evidently this can be remedied only by providing ample warehouses in convenient proximity to the wharves, and we believe that it is safe to say that the addition of 150 feet width to the State's property on the water front, as is outlined later in this report,* would possibly add fifty or more per cent. to the capacity of the port, as it would afford warehouse sites and relieve the congestion of the wharves.

Following the rule of 630,000 tons as the normal amount of freight to be handled over each mile of berth room, it is evident that the 47 miles of berth room which may be constructed on the ten miles of San Francisco water front, would accommodate an annual commerce of 30,000,000 tons, an amount greater than that which has been reported elsewhere and nearly double the commerce of London.

The number of piers or wharves which can be built in the water front area above referred to will depend upon their widths and those of the slips adjacent thereto. About 200 wharves of the average dimensions of those now in use could be constructed; but as many of the vessels building, and that may in the future be engaged in the commerce of the Pacific, will be larger than those now in use (see statistical chart for increase in length and average tonnage of steamships) it may be judicious to increase in width 20 or more of the proposed wharves to 130 feet or more and that of the adjacent slips to a width of 200 to 250 feet. This would reduce the number of wharves, as twenty of the larger piers with enlarged slips would occupy the space of about thirty of the present average piers and slips. The location of the larger piers will be determined by the requirements of the commerce of the future and should be left to the discretion of the Harbor Commissioners who are now tearing out old wharves between Harrison and King streets and replacing them with large, improved, modern piers.

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*See page 29.

FORECAST OF INCREASE.

What the commerce and requirements of San Francisco as a port may be fifty years hence is largely a matter of opinion and estimate. Any forecast must be based upon its past record and coupled with the general growth of the commerce of the Nation and of the World, all of which is to be considered with reference to the facts relating to the port.

Business in this city is growing much more rapidly than its population; the rate of increase both in population and commerce is not uniform, but is ever accelerating. Consequently San Francisco must in the near future have a commerce greatly in excess of any now existing, and predictions for estimating what her commerce will be at any time during the next fifty years must be based upon its growth in the past fifty years and also compared with that of other but perhaps less favorably situated commercial ports of the United States and of the world during the same period.

Judging solely from the growth of San Francisco's commerce during the past twenty years, she should have a commerce of 13,000,000 tons about twenty-five years hence, or, say, in the year 1932; but as the rate of growth of our commerce during the past five years is greater than that of the previous fifteen years, we should be prepared to handle a commerce of 13,000,000 tons at the expiration of about twenty years (1927).

STATISTICAL CHART.

A statistical diagram has been prepared and appended to this report to which attention is invited. Upon this chart will be found most of the statistical data, either relating to this port or general conditions of trade over the world from which inferences as to the future may be drawn. All of the data shown has a law of increase somewhat of the nature of compound interest.

Such data is best shown by a logarithmic platting which causes what would otherwise be curves to appear as straight lines of average value, and these, when exended on said chart, eliminate abnormal conditions and give estimates of average future values, many of which appear in this report.

While the only definite basis on which to forecast increase of trade in the future must be the record of past years, yet it is not improbable that the rate of increase of San Francisco's commerce may have entered upon a period of sustained acceleration.

CHART III.

A STATISTICAL CHART

SHOWING THE PROGRESS OF BANKING, COMMERCE, SHIPPING, POPULATION.

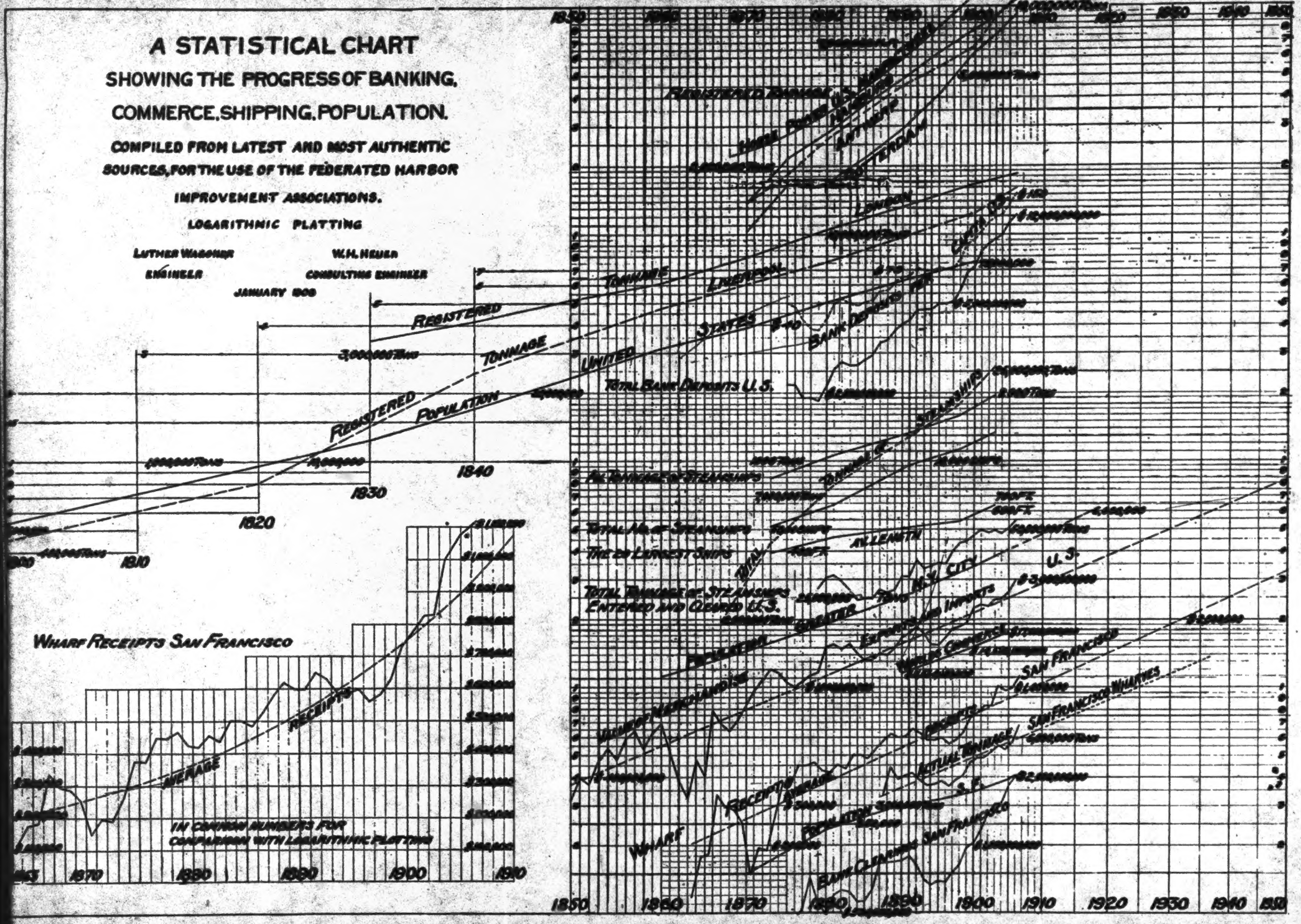
COMPILED FROM LATEST AND MOST AUTHENTIC SOURCES, FOR THE USE OF THE FEDERATED HARBOR IMPROVEMENT ASSOCIATIONS.

LOGARITHMIC PLATTING

LUTHER WAGONER
ENGINEER

W. H. HEUER
CONSULTING ENGINEER

JANUARY 1908



The reports of the last five years indicate that such is the fact, as also does the rapid increase in the total bank deposits in the United States, and especially of the bank clearings and sales of real estate in this city for the last ten years; since the increase in financial strength and the increase of commerce keep pace the one with the other. A new factor may at any time be introduced which will alter the rate of gain. The opening of the Panama Canal may accelerate in a marked degree the ratio of increase; and the vast possibility for development in the Oriental trade is as yet unrealized. It is to the Pacific Coast, and especially to California, that the world looks for the impetus which shall awaken the commercial forces of the Far East.

PART IV.

DEVELOPMENTS CONSIDERED.

In the foregoing section it has been pointed out that a commerce of approximately 30,000,000 tons annually may be provided for by the extension of docks along the ten miles of water front within the limits of the city and county of San Francisco. It remains to inquire how this may best be accomplished with an arrangement of piers and wharves adapted to the requirements of trade; and whether further development should be sought within or beyond the limits of this ten miles of shore. For before an amount of commercial activity, indicated by a commerce of 30,000,000 tons is reached, additional wharfage facilities for San Francisco must be sought and provided for in one or more of the following six ways:

PLANS FOR EXTENSION.

A. Development of the water front continued along the bay in a southerly direction beyond what is now the boundary line between San Francisco and San Mateo counties.

B. In case a Greater San Francisco were formed, embracing other cities on San Francisco Bay, construction of additional wharves on the Oakland side of the bay.

C. Cut down Yerba Buena Island and build up an adjacent shoal.

D. Acquire land, now submerged and in private ownership between India Basin and what is known as Islais Creek Channel, which would permit of an inner basin being formed in which nine additional wharves may be constructed to furnish more than four miles additional berth room.

E. Slips and solid piers may be constructed between Fort Mason and Presidio, as shown on Chart II. This will furnish 19,200 lineal feet of berth room.

F. Obtain permission from the Secretary of War to re-establish the bulkhead or seawall line 150 feet bayward of its present location, and for a corresponding alteration in the pierhead line, especially at Mission Rock, to furnish 5.3 miles additional wharf room, or 10.8 miles additional berth room, between Channel street and Hunters Point; or including that in paragraph "D," more than 15 miles additional berth room.

SAN MATEO SHORE.

Plan A—Requires legislative action to acquire additional territory now in San Mateo county. No harbor lines have yet been established by the United States Government on that portion of the bay in San Mateo county. The outer end of the wharves would terminate in twenty to twenty-eight feet depth at low water (the maximum depth in that part of the bay). All the submerged lands extending from 4000 to 8000 feet from the shore line into the bay and between the boundary line and San Bruno Point, a length of about 3.6 miles, have been sold by the State of California and are now held in private or corporate ownership. The line of deep water (20 to 28 feet) is 4000 to 12,000 feet distant from the shore line, and even though the submerged land should all be reclaimed by its owners, it would still require wharves from 3000 to 5000 feet in length and the slips would have to be dredged throughout their entire length. The entire system would be very expensive and could not be advantageously used until the land shoreward was reclaimed.

ALAMEDA COUNTY.

Plan B—In case a greater San Francisco be formed, the unimproved shores of the bay in Alameda county in front of the cities of Alameda, Oakland and Berkeley afford ample area for the construction of wharves, more than sufficient for all the commerce likely to be handled in this vicinity for the next fifty years. The objection to wharves on the east side of the bay before the peninsula side is congested is that commerce, which could more profitably and advantageously be handled from the San Francisco side, would require another transfer by barge, lighter or perhaps by a long railroad haul via Dumbarton bridge. The deep water in which the outer ends of the wharves on the Alameda side of the bay would terminate is in some places four miles distant from the shore line. The locality, however, can be economically wharved.

YERBA BUENA PLAN.

Plan C—Yerba Buena, or Goat Island. This island belongs to the United States Government and is jointly used by the army, navy and light house departments. It ocvers an area exceeding 100 acres, and has a height of 345 feet. Northeast of and adjacent to this island is a shoal area 1¼ miles long and nearly one-half mile in width, over which the depth of water is from one to eighteen feet at low tide. The shoal covers an area of about 400 acres. With the exception of this shoal, the island has deep water all around it. It is distant 1½ miles from the San Francisco water front, ⅜ of a mile from the Oakland end of the Key Route ferry wharf, and about the same distance from the outer end of the Oakland mole.

Many years ago (about 1870) efforts were made to have the Government transfer or grant this property to a railroad company with the object of making it the transcontinental terminus. It was desired to connect it with the Oakland shore by a dyke or roadway. Several efforts have since been made for the same purpose; the latest application, made several years ago, was for permission to use it, or a portion of it, for the end of a tunnel extending from San Francisco to Goat Island, thence to have rapid transit by ferry, causeway or other means to Oakland.

All applications to the Government to yield its ownership to the island or to any part of it for private or corporate uses have been persistently refused. The Government has probably expended more than a million of dollars in buildings and other improvements on the island now used for light house purposes and for a light house depot, a naval training station and as a warehouse for storing torpedoes. There is no other place in the bay so well suited for governmental purposes, nor is there any place on or in the bay so well adapted to termini for any and all transcontinental railways and other commercial uses.

If the property can be acquired by purchase from the Government at a fair price, the island can then be cut down to a horizontal plane, say about ten feet above extreme high tide level. The material cut away would build up the shoal area northwest to the same level, the whole forming an island having an area of between 500 and 600 acres, all of which would then be available for railroad yards, depots, workshops, warehouses and, in addition thereto, could be developed so as to furnish about eleven miles in length of wharves, or approximately 22 miles of berth room, available for ferries and commerce. There would have to be a steel bridge with draw opening capable of carrying at least four tracks as well as a wide road for vehicles, connecting the island with a shoreward pier on the Oakland side. The latter would be largely of protected piling, the openings to be so arranged as to offer the least interference to the flow of the tidal currents.

ISLAIS CREEK BASIN.

Plan D—The most serious objection that can be urged against the acquisition of the submerged land in the Islais Creek basin is its probable cost.

There is no other place on the whole water front of San Francisco which presents such favorable conditions for a perfectly protected inner basin capable of furnishing upward of four miles of wharfage room, and which is so convenient of access to the Mission and to the central part of San Francisco and the Potrero, which is rapidly growing and which has recently developed into a great railroad and manufacturing district.

The State will soon require the more than four miles additional wharfage room which the basin can afford. It cannot procure advantageously this amount of wharf room elsewhere, and it may be economy to purchase or acquire this property now rather than wait ten years or more, when the increase in the price of the property may be prohibitive to its acquisition. It is worth more to the State for harbor purposes now than to private owners when unreclaimed. Its cost of reclamation would approximate $5000 per acre. There are about 123 acres to be reclaimed, which will cost about $615,000. For harbor purposes no reclamation is necessary; on the contrary, dredging will be required. Something like four million cubic yards will have to be dredged to obtain a depth of 30 feet throughout this area. The cost should not exceed ten cents per cubic yard or, say, $400,000, for dredging. The spoil could be pumped and deposited in the submerged area south of First avenue and westerly, reclaiming a large area of now unused property.

This scheme presupposes that the lands acquired should be used for a basin south of Islais Creek as shown upon the map, and that a seawall would first be constructed; say south from Islais Creek along Massachusetts street, First avenue and India street, after which reclamation could proceed.

A sufficient number of owners might make an agreement with the State to improve their property behind this seawall after its construction. This would perhaps enable the matter to be successfully financed by the Harbor Commissioners and enable them to proceed with wharf construction in the basin so as to obtain a revenue from the proposed works.

If such an agreement can be made with the owners to reclaim, and a price for the land to be used for the basin be arranged upon a basis of its assessed value rather than a speculative estimate, its purchase for harbor purposes cannot be too strongly urged.

SLIPS BETWEEN FT. MASON AND PRESIDIO.

Between Fort Mason and Presidio the deep water is close to the bulkhead line. The locality is exposed to strong currents and wave action; interior slips and solid piers are indicated for this district. The areas designed for slips are in private ownership.

CHANGE IN HARBOR LINES.

Plan E—The establishment of the bulkhead and pierhead lines farther out from the shore, if permitted by the Secretary of War, would accomplish more than the acquisition of greater areas distant from the wholesale and manufacturing centers. By relocating the bulkhead, or seawall line, 150 feet bayward of its present position a tract of land of that width along the entire harbor front would be reclaimed by the State, which would be of great value, and the revenue from rentals of warehouse sites should repay the cost of reclamation. By extending the pierhead line a similar distance piers might be constructed of undiminished length; and by establishing this line outside Mission Rock, docks of greater length might be constructed in front of China Basin, which would add 10.8 miles of berth room in a locality adjacent to the present centers of commercial activity.

THE BULKHEAD LINE.

The object in extending the bulkhead line is to widen the street next to the water front 150 feet, on which warehouses, so necessary to the accommodation of the commerce of this port, may be built and the Belt Railroad extended. These warehouses will be specially advantageous to commerce, due to their proximity to the shore ends of the wharves, in that no drayage will be necessary between wharf and warehouse, and it will eliminate the use of wharf sheds for warehouse purposes. Such warehouses have been built on the latest improved Bush docks at South Brooklyn, New York.

This will permit the use of the piers for their proper purposes and greatly increase their capacity. Freight that cannot be hauled away with sufficient rapidity can be stowed upon the open wharf space between the piers, seawalls and warehouse; or in the warehouse, from which it can be removed by teams or by the cars of the Belt Line Road, one track of which should lie close to warehouses for such purposes.

This strip of submerged land, 150 feet wide and eight miles long, owned and controlled by the State of California, contains about 143 acres, and if filled in would reduce the tidal prism of the bay by that amount of acreage. This will be practically compensated if Islais Creek basin be acquired and utilized, as it covers an area of nearly the same acreage.

There are about eight miles of seawall yet to be built along the entire water front. The cost of constructing a seawall on the proposed new bulkhead line will slightly exceed that on the existing line, due to a slightly increased depth of water. But the strip of land which the State will thus acquire, and which can then be either improved or leased for commercial purposes, should produce a handsome revenue. The value of the land would probably pay for the cost of construction of the entire seawall. Where the seawall has been completed, it may not be necessary or advisable to incur the expense of increasing its width or thickness by 150 feet. If it be desired, warehouses can be built on concrete piles and steel girders on the outer slope of the present wall, and the wharves can then be extended in length to reach the newly proposed pierhead line as required.

The Pierhead Line.

The object of extending the pierhead line between Nineteenth street and Hooper street extended, and including Mission Rock, is to permit the construction of docks of greater length where the depth of water is not prohibitive, and where they will be of great commercial value.

The existing pierhead line as established many years ago between Hunters Point and Nineteenth street, a length of about 2.33 miles, is distant from the bulkhead line 600 feet, in water ranging between 20 and 36 feet in depth. From Nineteenth street north to Channel street the length is a little more than a mile, in which the pierhead line varies in distance from the bulkhead line, from 180 feet to a little less than 600 feet. It is here that Mission Rock lies about 900 feet outside the pierhead line, and a wide passageway was left between Mission Rock and the shore, in which there is a maximum depth of 48 feet and a channel having a least depth of 30 to 36 feet. The pierhead line for three-quarters of a mile in length shoreward of Mission Rock is only 180 to 300 feet distant from the bulkhead line; this limits the length to which wharves may be built. Twenty piers or wharves might be constructed between the existing harbor lines at this locality with a total length of 5660 feet, or an average of 283 feet each, but wharves of such short lengths are but poorly adapted to the present or prospective commerce of this port.

In this connection attention is invited to the statistical chart showing the growth of steamships in the past thirty-five years. The average tonnage of a ship has increased from 790 tons to about 2300 tons at the present time and if the rate of increase be maintained for the next twenty years, we may expect to see the average tonnage exceed 4000 tons. Similarly there has been a great increase in the length of steamships. The twenty largest ships in 1873 averaged about 390 feet in length; at present it is about 690 feet. The Panama Canal is now planned to have locks to accommodate vessels 1000 feet in length by 100 feet beam.

In consequence of the rapid growth in the size of ships in the past and the certainty of their continued increase in dimensions, which is only limited by the actual prevailing harbor accommodations at the greater ports of the world, it is thought that the pierhead lines should be extended outside of Mission Rock, as shown upon the map and plan herewith submitted.

With this extension of the pierhead line around Mission Rock it will be possible to construct at reasonable cost 15 modern wharves, aggregating about 17,000 feet in length, averaging 1138 feet in length. This will furnish 34,000 feet (or nearly 6.5 miles) of available and very necessary berth room located in a district adjacent to several railway lines having their termini close by; and without any detriment to navigation. It would be a very decided benefit to commerce and could be made to produce revenue to the State, as well as provide for the further extension of the needed works of the port.

The wharves as projected in front of the Central Basin would deprive the Union Iron Works of the use of its present launching ways which could be replaced by others whose axes would be nearly parallel to Nineteenth street, and which would permit of launching direct into the bay instead of into Central Basin.

CONCLUSIONS.

Of the various plans outlined for getting increased wharf space, the following appears to be the relative order in which it should, when necessary, be obtained:

1. Extension of harbor lines, particularly at Mission Rock.
2. Islais Creek basin.
3. Between Ft. Mason and Presidio slips.
4. Alameda county shore.
5. Goat Island.
6. Extension of water front into San Mateo county.

In addition to what has been said about the Islais Creek basin as a valuable site for wharves within the basin, it may be added that it would be injudicious to construct any seawall or wharves of any kind between India Basin and the channel of Islais Creek extended, until it has been fully determined whether or not the State is going to acquire the submerged area in the basin. If it should acquire the basin, the inner wharves and walls along India street and First avenue, South, should be built first. If it should not acquire the basin, it would be exceedingly imprudent before the lapse of several years to build a seawall along what is known as the bulkhead line, for such a wall would cost about half a million dollars, to which must be added that of any wharves that may be built from it channelward. As there would be no connection between the wall or wharves and shore, there would be no commerce, and consequently no revenue to the State for the money thus expended, until the area behind the seawall was reclaimed. As the property is still in its natural condition, and cannot be reclaimed advantageously until a seawall be built in front of it, it is suggested that an agreement might be made that the State construct the wall in sections and the land owners agree to concurrently reclaim their lands in the rear of the embankment.

In the matter of changing harbor lines to afford increased commercial facilities, the law requires that permission to make such change as is necessary must be obtained from the Secretary of War. It is therefore recommended that application be made by the Governor of the State, or by Harbor Commissioners, for permission to make a new seawall or bulkhead line 150 feet outside (channelward) and parallel to the existing bulkhead line throughout the entire length of the water front of the city; and to authorize a new pierhead line parallel to and 800 feet distant channelward from the proposed new bulkhead line—commencing at the boundary line of San Mateo and San Francisco counties extended easterly and continuing thence along the water front to the west line of Van Ness avenue extended. All parts of this line are to be parallel to and 800 feet outside the proposed new bulkhead line except that portion lying between the north line of Nineteenth street, extended in an easterly direction, and the south side of Hooper street extended in a northeasterly direction, where the proposed new pierhead line is to pass outside of and tangent to the extreme easterly point of the wharf line of Mission Rock as established by the Secretary of War, March 24, 1890.

The change recommended in the portion of the pierhead line between Nineteenth street and Hooper street extended may be described as follows, viz.: Beginning at a point lying on the north side of Nineteenth or Butte street extended in an easterly direction and distant on said line 1240 feet in an easterly direction from the northwest corner of Delaware and Nineteenth streets, which point of beginning is also 950 feet distant and on a line parallel to the existing bulkhead line; thence in a northerly direction tangent to the extreme easterly point of the Mission Rock wharf line authorized by the Secretary of War March 24, 1890; thence from said point of tangency in a direction slightly west of north to a point on the easterly extension of the south line of Pier No. 44, 950 feet distant in an easterly direction from the existing bulkhead line.

Accompanying this report is a chart showing an arrangement of wharves and piers within the harbor lines designed in accordance with the recommendation herein. It will be possible to handle over these wharves so arranged an annual commerce of 30,000,000 tons.

It is not expected that the dimensions of the piers and slips as shown on this chart will be rigidly adhered to. They will vary in length and breadth in accordance with the future requirements of commerce. Near Mission Rock the chart shows piers 1100 to 1200 feet in length. When first built they would probably not exceed 600 to 800 feet in length, which could be increased when necessary to accommodate larger vessels.

As the city grows in population additional ferry accommodations for passengers and freight will be required. The exact location of the new slips cannot be determined at present. One of the ferry lines may be established on the northern part of the water front, possibly somewhere near the foot of Van Ness avenue. Another may be required in the vicinity of Islais Creek. When constructed they will each occupy about as much water front as one of the wharves and an adjacent slip estimated for and shown on the map.

PART V.

PROBLEMS OF CONSTRUCTION.

Construction problems in the improvement of the harbor front are limited to the building of the seawall on the bulkhead line, and the erection of docks. The only serious difficulty to be met is in securing a suitable and economic form of support for the docks, especially at their outer ends, where the water is of considerable depth, and the bottom is a mud of varying density and uncertain depth.

The execution of the work as outlined will require eventually large amounts of material and the wise selection of economic plans will result in a saving to the State, directly benefiting the port, of a sum which will reach into the millions of dollars.

The completed work will require the use of over 100,000 piles, and careful consideration should be given to this subject, so as to secure the greatest strength in the structures as well as maximum economy in first cost and maintenance.

DESCRIPTION OF SEAWALL.

There are yet eight miles of seawall to be built, the method of construction of which is as follows:

Inside the bulkhead line a trench is first dredged in the mud to a depth of from 20 to 35 feet below tide level, and from 20 to 30 feet wide at the bottom. This is then filled with loose broken rock, and an embankment of the same material is constructed, generally measuring about 100 feet at its widest part, and gradually narrowing in width as it approaches the top or grade plane, which is thirteen feet above the plane of low tide level.

Above the plane of low tide, and up to the grade plane, the outer or sea face of the retaining wall is paved with a thickness of four feet of very heavy rock. Below the low water line the outer face is covered with rock, each piece weighing 400 pounds or more.

On this outer face an apron or wharf of wood, 60 feet wide and supported on wooden piles, has been constructed, on which the shore ends of the various wharves abut.

Behind the seawall is the street or thoroughfare; the filling being of sand, broken rocks, dry earth or other suitable material. When this is sufficiently settled the street is macadamized or paved.

This type of seawall is admirably adapted to this locality. It might advantageously be modified by using protected concrete covered piles for the trestle during construction, and afterward using the same piles as supports for the wharf or apron, which should also be permanent in character.

Inside the basins to be constructed, as previously described. the embankments might be built of dry earth or other suitable material, heavily faced with rock. Both earth and rock might be obtained from the hills in the rear of the basins. The embankment should be at least 200 feet in width or thickness before dredged material is placed behind it.

PIERS AND PILING.

The nature of the soil at the bottom of the bay is an important factor in pier construction. For this reason it is given a somewhat detailed notice here with an account of tests made to determine the bearing power of the piles, their penetration into the mud and their protection from the ravages of the marine worms.

Borings 200 feet in depth have been made in the bottom of the bay along the water front, and test piles have been driven by direction of the Harbor Commissioners. Piles have also been driven and tested by the Government at Fort Mason. All experiments made here show conclusively that the density of the soil increases with the depth, but not uniformly. Hard bottom, if found, is at such depth as to make it impracticable to reach it with piles, and consequently such piers or wharves as have been and will in future be constructed in such bottom must depend for stability on the friction between the piles and the mud.

Tests Made at New York.

Interesting tests were made near the foot of Twenty-third street, North River, New York City, in 1902, by the dock department to determine the actual bearing power of piles in soil which appears from the description to be identical in character to that along our water front. In the experiments made twenty wooden piles were used. They were from 79 to 85 feet in length; from 14 to 22 inches in diameter at the butt and 5 to 10 inches in diameter at the point. Each pile was driven in water about 23 feet deep and to a penetration in the mud varying between 45 and 52 feet. A careful record of the driving of each pile was kept, showing:

(a) The depth of penetration into the mud by its own weight.

(b) Additional penetration due to the weight of the hammer (3300 lbs.).

(c) Penetration due to each blow from the hammer falling ten feet and the penetration obtained at the end of every five consecutive blows.

(d) Final penetration due to each blow in the last five blows.

The piles were arranged in three groups of four piles each and one group of eight piles. A platform was constructed on each group. This was loaded with gradually increasing weights for 27 days, and then allowed to remain another 27 days, noting the subsidence of each pile in each platform until collapse or destruction occurred.

Of the twenty piles above referred to, twelve of them were prepared by bolting and spiking to each four pieces of 5x6-inch timber 30 feet in length, their lower ends being five feet above the point of the pile. Four were prepared by bolting two pieces 5x6 inches and two pieces 4x10 inches of lagging, each 30 feet long, on each pile. The other four had no lagging whatever on them. The object in lagging was to determine, if possible, the increased load such piles would sustain due to their increased sectional and superficial areas.

The results briefly stated are that the weight of the piles alone caused them to penetrate the mud to a depth of 8 to 15 feet. The average penetration was about 11 feet; the weight of the hammer caused an additional average penetration of 7.5 feet. At the tenth blow of the hammer the average penetration of the unlagged piles was 32 feet, while that of the lagged piles was only 17 feet.

The unlagged piles required an average of 17 blows of the hammer to get full penetration, viz., about 49 feet, while the lagged piles required each an average of 63.7 blows (10 feet fall) to obtain about the same penetration. With the unlagged piles the last five blows caused penetration of three feet, or an average of 0.6 foot per blow, while with the lagged piles the average penetration for the last five blows was 1.2 feet, or an average of 0.24 foot per blow. In the final tests on the loading platforms, the unlagged piles sustained each a weight of 18.7 tons, while the lagged piles sustained weights varying between the limits of 28 and 34.6 tons. All platforms settled somewhat in the 27 days while loaded, the maximum subsidence of any pile was 1 11/16 inches.

In the San Francisco Harbor Commissioners' report for 1899 there is a record of a test pile 90 feet long loaded with 45 tons for 48 hours without any subsidence. At Fort Mason a test pile 88 feet long driven 53 feet into the mud penetrated 1 inch at last blow of a 4000-pound hammer, dropping 15 feet. This pile was loaded with 48 tons of pig iron for 60 hours; no subsidence occurred.

From the test piles driven here and elsewhere in a soft, muddy bottom in which the density increases with the depth, it is evident that to be effective the piles must be driven to a penetration of 50 feet or more—and that the sustaining or bearing power of the piles increases with increased penetration, also with increased horizontal cross section, as well as superficial area of the pile, and that the best results obtain when the increased area is in the denser and more resistant soil near the lower end of the piles. The New York experiments indicate that the lagged piles in the lower 30 feet of their lengths, presenting about double the superficial area of the unlagged piles, sustained nearly twice as much weight as the latter. The cost of the lagging would add about 30 per cent to the cost of the pile driven, while the bearing power of the lagged pile is nearly 100 per cent more efficient.

Types of Cylinders Used.

While a pile thus prepared has a greatly increased bearing capacity, it needs further protection against rot and destruction by the Teredo and Limnoria. The marine worms act between the mud line and the surface of the water; decay occurs above the water line. The most effective protection is that which is most permanent, readily applied and least in cost. Many kinds of chemical treatment, as well as various kinds of covering, have been tried here. Asphalt, coal tar, bitumen, paraffine paint, creosote, canvas, burlap and wood covering have all been used singly or in combination, and valuable experience has thus been obtained; but complete permanent protection was not secured.

In 1895 boiler iron cylinders 3/16 inch thick, 4 feet in diameter and averaging 45 feet in length were used to inclose clusters of three piles; the cylinders were then pumped out and filled with concrete. They afforded protection for the wooden piles, but the iron cylinders were expensive, liable to injury or destruction, especially in case obstruction was encountered while being driven, and they were difficult to maintain in a water-tight condition, while being pumped out preparatory to being filled with concrete. Two piers (Pacific and Folsom streets) were constructed in which metal cylinders were used.

Afterward a wooden casing or cylinder four to five feet in diameter was substituted. The staves were dressed and beveled, are about 4 inches thick, assembled and held together by wrought iron bands, or hoops, spaced about 24 inches apart, the combination forming a water-tight cylinder of any required length; this is driven into the mud to a depth of 15 feet, more or less, in the same manner that the inclosed pile was driven. Some of the mud into which the cylinder has been driven is then removed or pumped out and is replaced by bags partly filled with green concrete. Portland cement is also thrown in around the wooden pile or piles within the cylinder for a height of five or six feet and is allowed to set. This makes a reasonably water-tight joint at the bottom of the wooden cylinder. The water is then pumped out and the cylinder is filled with concrete.

The wooden cylinder has many advantages over the metal casing. It is cheaper to build; is far stiffer, easier to drive, not liable to collapse when pumped out and makes an excellent form for the concrete within, and is neither necessary nor useful after the concrete has had an ample time to season. It is the invention of Mr. Howard C. Holmes, is patented, and for its use a royalty is paid. All piers built in the past ten years have been constructed with the use of these wooden cylinders. In a few years the marine worms destroy the wooden cylinder or covering, the wooden bearing piles being still protected by a thick concrete covering. This system, while effective, is expensive, and an effort has been made by us to reduce this cost.

Sketch of the protected pile recommended and estimated for use in this report for wharf construction:

Fig. 1. View of the lagged pile and steel driving cylinder resting upon the concrete disc, ready for concrete protection.

Fig. 2. View of the lagged pile, steel driving cylinder removed. Shows the hooped form that has been filled with concrete, resting upon the concrete disc. Four iron rods extending from the concrete disc to upper part of the pile or to grade. Also shows metal reinforcement surrounding the four rods which serve to center the reinforcement and keep it uniformly distant from the wooden form.

Fig. 3. Sectional view of the concrete disc, showing two of the four attaching rods; also shows a grommet which, compressed by the resistance of the soil, is forced into the conical disc and prevents the mud from entering the wooden form.

New Method Described.

One of the methods now suggested as being practical and worthy of consideration is as follows: Obtain a dozen heavy iron or steel cylinders—say ⅜ of an inch thick—28 to 30 inches outside diameter and from 40 to 60 feet in length. They can be driven and will not collapse when pumped out. These are made in standard sizes and lengths by the National Tube Co., Pittsburg, and can be obtained in any length required. After the lagged wooden pile has been driven to a sufficient penetration, preferably butt foremost, cut it off between high and low water levels. Attach temporarily to the bottom of the steel cylinder a hollow concrete collar or disc, with a cutting or interior beveled edge at its bottom. Slip loosely over the pile a grommet of straw (collar) several inches thick inclosed in bagging. Insert inside the iron cylinder a light sheet iron slip-jointed cylinder, or a wooden one made of 1-inch thick "T. & G." dressed lumber bound together by thin steel hoops about two feet apart. The outer diameter of the wooden or sheet iron cylinder will be 26¾ or 28¾ inches. Now slip over the driven pile the two combination cylinders, having the concrete collar attached by lugs and iron rods to the inside top of the outer cylinder. As this is lowered the grommet slides along the pile in the cup-shaped cavity of the concrete disc. Drive the cylinders and attachments 10 or 15 feet, more or less, into the mud. Release the lower concrete disc from its fastenings inside and near the top of the cylinder. Bring the top of the four rods carrying

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tight, leaving pumping out.
Then pump pile outside
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The cost is estimated
to be about $ half that of
the system at

FIG. 3

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FIG. 1 FIG. 2

SKETCH OF THE PROTECTED PILE

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*Sketch of th nated for
use in this report*

Fig. 1. Vie cylinder
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Fig. 2. Vie linder re-
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New Method Des

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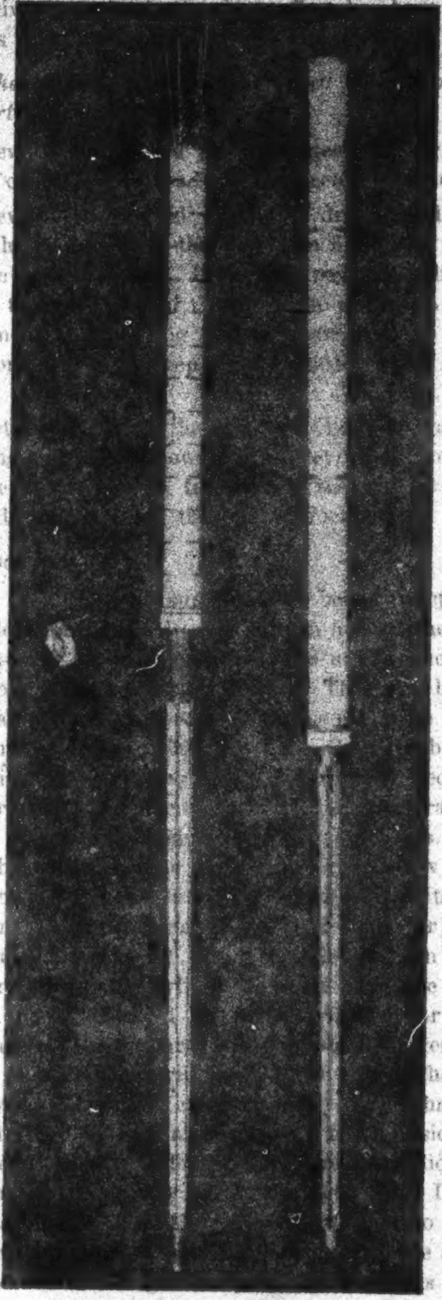


FIG. 3

FIG. 2 FIG. 1

SKETCH OF THE PROTECTED PILE

this disc together and secure them around the top of the sawed-off wooden pile. The grommet at the bottom, the concrete disc and penetration into the mud should make the cylinder nearly water tight, leaving the interior free of mud and ready for pumping out. Then pump out the water and slip over the wooden pile outside the iron rods a steel cage of Clinton wire cloth to be used for reinforcing, and then drop in wet concrete until the inner wooden or sheet iron cylinder is filled; then withdraw the outer iron cylinder for use on any other pile ready to receive it. The concrete covering surrounding the wooden pile will be from 5 to 8 inches thick, ample for protection and insuring greatly increased lateral stiffness.

The wooden or sheet iron inner casing will cost only about one-fourth as much per linear foot as the heavy wooden casing now in use; will be strong enough to resist rupture from the green concrete within; will enable the outside iron cylinder to be withdrawn as soon as the inner cylinder is filled, the only friction being that of the outside surface of the cylinder with the mud, which cannot be great, as it will generally be withdrawn in a few hours, and before the earth has much opportunity to pack around it.

The cost of a complete covering as above described is estimated to be about $2.60 per linear foot, which is about one-half that of the system at present in use.

While the piles or columns as above described will probably exceed in carriyng capacity that of the average pile now in use under existing piers, and would therefore permit of their being spaced farther apart to carry the contemplated load, thus reducing the number of supports required and thereby further reduce the expense of wharf construction, no reduction in the number of separate bearing piles is recommended. The extra bearing power furnishes a greater factor of safety against subsidence and also permits the constrction of two-storied sheds on the wharf should such be desired.

Near the outer ends of the wharves where the water is deep (30 to 40 feet) and the upper 15 or 20 feet of the mud has little resistance to compression and almost none against lateral movement, the height of the columns supporting the wharf are unusually great, and there it is proposed to use the 30-inch or larger diameter cylinders. It might be well to brace these columns horizontally at or near the mud line by throwing in 10 to 15 tons of rock (cobbles or one-man stone) around each column. This will add greatly to the rigidity of the piles and to the stiffness of the wharf.

SOLID FILLED PIERS.

To better protect the piers and shipping thereat from the effect of winds and strong tidal currents it is advisable to build certain solid filled piers extending beyond the established or proposed new pierhead line. We have marked upon the map herewith submitted such piers. They would be built with faces of loose rock and piling upon the sides so as to serve as wharves, and by reason of the solid fill cut off the tidal current and thus give protection for a considerable space on either side to the shipping.

Such piers would be available to deliver the sewage beyond the pierhead line, and they would also have lights and fog bells at their outer ends. As they are to be filled solid and extend beyond the bulkhead line, permission for this construction must be first obtained from the Secretary of War.

It is suggested that these piers should remain open wharves, i. e., not leased, and that it might be advisable to equip one or more of them with traveling cranes.

The present site of the Fisherman's wharf, at the foot of Taylor street, will probably have to be rearranged, especially if the bulkhead line is advanced 150 feet as suggested. We believe that a permanent haven for the fishing fleet can best be had by placing it alongside a solid filled pier, and if required for protection the slip could be partially closed by widening the pier at its outer end, solid filling the same.

Decks of Wharves.

The question of deck covering for wharves for San Francisco has been given careful consideration. Plans for reinforced concrete decks for new piers have been made by their engineer and submitted to the State Harbor Commissioners. The Department of Docks of Greater New York contemplates the use of reinforced concrete 9 inches thick covered with a wearing surface of asphalt 2¼ in. thick for decks on the new piers to be built at South Brooklyn Concrete with a wearing surface of asphalt has been estimated upon instead of a wood floor as now used. A concrete floor will cost fully 33% more than a wooden floor and will weigh nearly twice as much per square foot of floor area. Its advantages are that it will be fireproof and, barring accidents or serious injury by earthquake or subsidence, will be much more durable and may cost less for maintenance. Its disadvantages are its weight and excessive cost and time required for construction and seasoning and expense of reconstruction in case of fracture or serious injury.

The experiments soon to be made with reinforced concrete decks for piers, both here and in New York, should furnish valuable data which may largely influence wharf construction in the future. With information now available, and bearing in mind the favorable results thus far obtained, it is deemed judicious for the present to adhere to the wooden decks, supported on heavy wooden joists; the latter carried on steel I beams, well braced horizontally, as is now being done on the Lombard street wharf.

SHEDS ON PIERS.

It is observed that about one-half of the docks here are covered, or partly covered, with sheds. The material used hitherto in the construction of the sheds has been wood. They are generally one-story in height; the Pacific Mail Dock—Pier No. 44—has been recently constructed with a two-story shed.

Whether or not two-story sheds should be built in the future may well be left to the wishes of the lessees. Where they are desirable the upper story should be planned for office rooms, and in no case should either the first or second story be used for warehousing goods. A one-story shed costs approximately 40c a square foot, while two-story sheds cost about 71c to 72c a square foot. It is certain that if lagged piles be used to support the docks—as herein referred to—they will be fully able to carry the additional weight of a two-story shed.

It would be possible, if in the future it should be desired, to construct a two-story shed at one of the solid filled piers, before described, using the lower floor for the usual traffic and renting the upper floor to the city for a "Recreation Pier," such as are used in New York city.

In the matter of fireproof covering, galvanized iron has been tried, but has rapidly deteriorated from rust and chemical action. At Boston the manager of certain docks has covered the roof trusses from the bottom chord of the truss close up to the roof, with asbestos boards to prevent the rapid spread of fire from cargo on the dock, and this form of construction enjoys a very low insurance rate. In New York city all sheds on piers are built at the expense of the lessees on designs first submitted to the Dock Commissioners for their approval. Fire rarely originates in the framing or covering of a shed, but more often in the merchandise stored in the shed. Failure to check such fires in reasonable time may result in the destruction of the shed whether it be built of wood or of steel. The wharves are generally so far apart—from 150 to 200 feet—that fire in one shed ought not to seriously endanger adjacent piers. There have been few fires on the wharves here in the past. Fireproof construction is expensive, and perhaps it would be unwise at present to burden the revenue with such a cost. Hence it may be advisable to build as heretofore. Should the revenues in the future permit, sheds requiring renewal might be replaced with ones having greater fire resisting capacity.

USE OF CRANES ABROAD.

In most harbors of Europe cranes are provided on the docks for moving cargo in discharging and loading. In fifteen larger European ports there is an average of one crane to every 53,300 tons of annual commerce, and to every 283 lineal feet of quay. They are either fixed or movable; and either electric, hydraulic or steam.

American practice differs entirely from the European custom in this matter. Here we have practically no cranes, the cargo being hoisted and lowered by means of the ship's tackle. Steamers are conveniently arranged for handling their cargo with their own steam, and in the case of sailing ships the Master Stevedore supplies portable steam hoists whenever it is necessary or advantageous.

Two floating cranes, one of from 100 to 150 tons, and the other of about 30 tons capacity, would be very useful in this harbor. In fact, no great port can be considered fully equipped without a floating crane of sufficient size to be serviceable in emergency cases.

To equip this port with as many cranes as are found at the average of foreign ports would perhaps cost $25 per foot of berth room; and if so equipped at least 75 per cent. of the cranes would be idle.

We have suggested (page 40) that the solid filled piers might be so equipped, and this suggestion might be extended to other open wharves where there is a public demand for such service. The whole matter is one of detail that should properly be left to the discretion of the Harbor Commissioners.

Further than this, the subject may be summed up by saying that there has been no general demand for cranes in American ports, and that it is reported that the rentals of those on the London docks do not pay the interest on their first cost. If the method of handling cargo mainly from the booms and hoists on the steamers had not been found expeditious and satisfactory in practice, American ingenuity would have been quick to take advantage of better methods. Following is the summary of crane equipment at seven European ports:

LONDON on its docks and warehouses has 1336 cranes and lifts in use, five of which are floating cranes.

BREMEN has 83 movable hydraulic cranes having arms from 10 to 12 meters long. Of these 51 have a capacity of 1½ tons, 20 of 2 tons, and 1 of 10 tons. One is a fixed crane of 26 tons capacity for handling coal, and five movable and ten fixed cranes transfer goods from shed to warehouse without disturbance of street traffic.

BREMERHAVEN has 14 cranes, of which five have capacities of from 2 to 12½ tons, six are steam cranes with capacities of from 1½ to 75 tons, and three are water, gas or electric, with capacities of from 25 to 150 tons.

LIVERPOOL docks have cranes of 15 tons or less, free to vessels paying dock tonnage rates and for goods landed if removed from the quay within two days after landing; thereafter an extra charge is made as follows:

For hand cranes less than 10 tons	6 hrs.	$ .12
	24 "	.25
Exceeding 10 tons and less than 25 tons	6 "	1.25
	24 "	2.50
Hydraulic cranes, 50 tons	3 "	15.00
	6 "	25.00
	12 "	40.00
Hydraulic cranes for over 50 tons	3 "	40.00
	6 "	60.00
	12 "	100.00

Many of the cranes at Liverpool are on warehouse roofs, where they travel on a track one rail of which is over the wall nearest the quay, the other on the peak of the roof. The arm or jib has a swinging motion on a vertical axis.

HAMBURG has 631 movable cranes, of which 273 are steam, 1½ to 2½ tons capacity; 263 are electric of a capacity of 2½ to 3 tons; 95 hand cranes have a capacity of 1 ton each, and one revolving crane (steam) has a capacity of 150 tons. Electric cranes cost about $6037 each. The most modern cranes are run on wheels on elevated tracks and goods cars pass underneath. One vertical support of the elevated track carrier is secured near edge of dock; the other (a horizontal girder) rests on and against the wall of the warehouse.

ANTWERP—The rates for use of cranes are complicated, and while some are charged for by the day, others are charged by the quantity and weights of goods handled. There are many straddling cranes under which goods cars can pass.

ROTTERDAM—The charges for cranes of 1½ tons capacity are $4.00 per day; for larger cranes having a capacity of 10 tons the charge is about 30 cents per ton up to 5 tons weight; 40 cents per ton up to 10 tons weight; above 30 tons the price increases per ton.

ELEVATED BOULEVARD.

As rapid transit along the water front is already a necessity and its need will be constantly increasing, it is suggested that an elevated transit passenger road might pass over the line of warehouses without in any degree detracting from the value of the space below for storage.

Mr. D. H. Burnham advises the undersigned that any plans for the future should include the possibility of making an elevated boulevard along the water front. He suggests that ultimately solid brick or concrete warehouses might replace the temporary structures on the proposed 150-foot strip of land to be acquired, and the elevated boulevard might pass over or on the roofs. Nothing in our plan precludes the adoption of such an idea if, in the future, it be desirable.

EXTENSION OF BELT RAILROAD.

The extension of the Belt Railroad and its early connection with the railway termini we consider of the utmost value to the present and future requirements of commerce. In the existence of the Belt Railroad and its operation under public ownership there has already been obtained an advantage which has been found difficult to acquire in other large cities on account of vested interests, land damages, etc. In New York a special commission reported in favor of a Belt Railroad, but it is the opinion of the present officials there that it cannot be consummated. Our plans are all on the line of an extension and enlarged usefulness for the Belt Railroad at San Francisco.

The acquisition of the proposed strip of 150 feet along the water front will afford an easy approach for the tracks of the Belt Railroad to the piers. While it is doubtful if many of the docks will require such tracks, it is certain that some piers can be worked to better advantage by having direct rail service, the tracks being laid flush with the deck and down the middle of the pier.

The disposition of the Belt Railroad tracks at the crossing of Market street in front of the Ferry Building is a part of a complex problem of congestion on the water front demanding radical solution. This congestion at Market and East streets of vehicles of all sorts, electric cars and pedestrians is serious, and is becoming more dangerous as the street traffic which converges at this point continues to increase.

After much consideration of this important question it is our opinion that the Belt Railroad should remain at the street level and that the tracks, where they cross Market street, should be laid under an elevated structure, more fully described in the following section, designed to carry the electric car loops, and a wide passage for pedestrians across East street, thus completely separating the different kinds of traffic.

By such arrangement freight cars can be moved at all hours on the Belt Railway, without inconvenience or danger to any one. Steam freight trains are constantly operated in the busy parts of Liverpool; the locomotive being preceded by a signal man carrying a flag and ringing a bell; and there have thus far been no accidents to persons or property. This method can be adopted at the foot of Market street, and in combination with the proposed elevated structure will allow the different kinds of traffic to cross without inconvenience or danger to either.

We have also considered a proposed subway through which the Belt Railroad might cross Market street. The principal objection to this, aside from its expense, is the two long approaches on either side, which would be open cut, and would prevent any crossing of the Belt Railroad tracks by teams for at least 800 or more feet, both north and south of Market street.

The same remarks apply to the proposed elevated crossing for the Belt Railroad along Main and Drumm streets, where the inclines required at each end would necessarily close several of the cross streets, but nothing in our recommendations precludes the use of Main and Drumm streets, for an additional cross-town connection, if in the future it be found desirable.

Another plan which we have considered involves a subway crossing for pedestrians from the Ferry Building to a point near the gore of Sacramento and Market streets, and a branch to the south sidewalk of Market street, the subway to have an opening or station between the two loops of the street car tracks as a means of reaching the cars above. Together with this it has been proposed to move the street car loops a slight distance west and thus to provide space for the belt Railroad tracks to pass between them and the Ferry Building. This plan attempts to separate the pedestrian from the vehicular traffic, but it by no means completely solves the problem.

ELEVATED LOOP AT THE FERRY.

The elevation of the electric street car tracks at the foot of Market street offers, in our opinion, the key to the most complete and permanent solution of the problem of traffic congestion on East street in front of the ferry. This requires joint action by the city and State. A plan to accomplish this, which has been designed by Sherman A. Jubb, C. E., is incorporated in this report. It is for an elevated loop over the site of the present tracks, or approximately so, and rising from the street by a 4 per cent. incline, beginning at the east line of Spear street.

From the level of this raised platform passengers would pass directly into the second story of the Ferry Building and to the upper decks of the boats. The plan also provides for stairs to ascend from both sides of Market street to an elevated platform on the outer side of the outer loop, over which pedestrians coming down Market street might pass over East street and into the Ferry Building at the same level as the street car passengers; thus separating these two lines of travel and removing both from the interference of teams and the proposed crossing of the Belt Railroad on the street level under the elevated structure. At the same time the vehicular traffic along East street would be free from interference from the constant succession of electric cars, which would pass overhead on the raised loops.

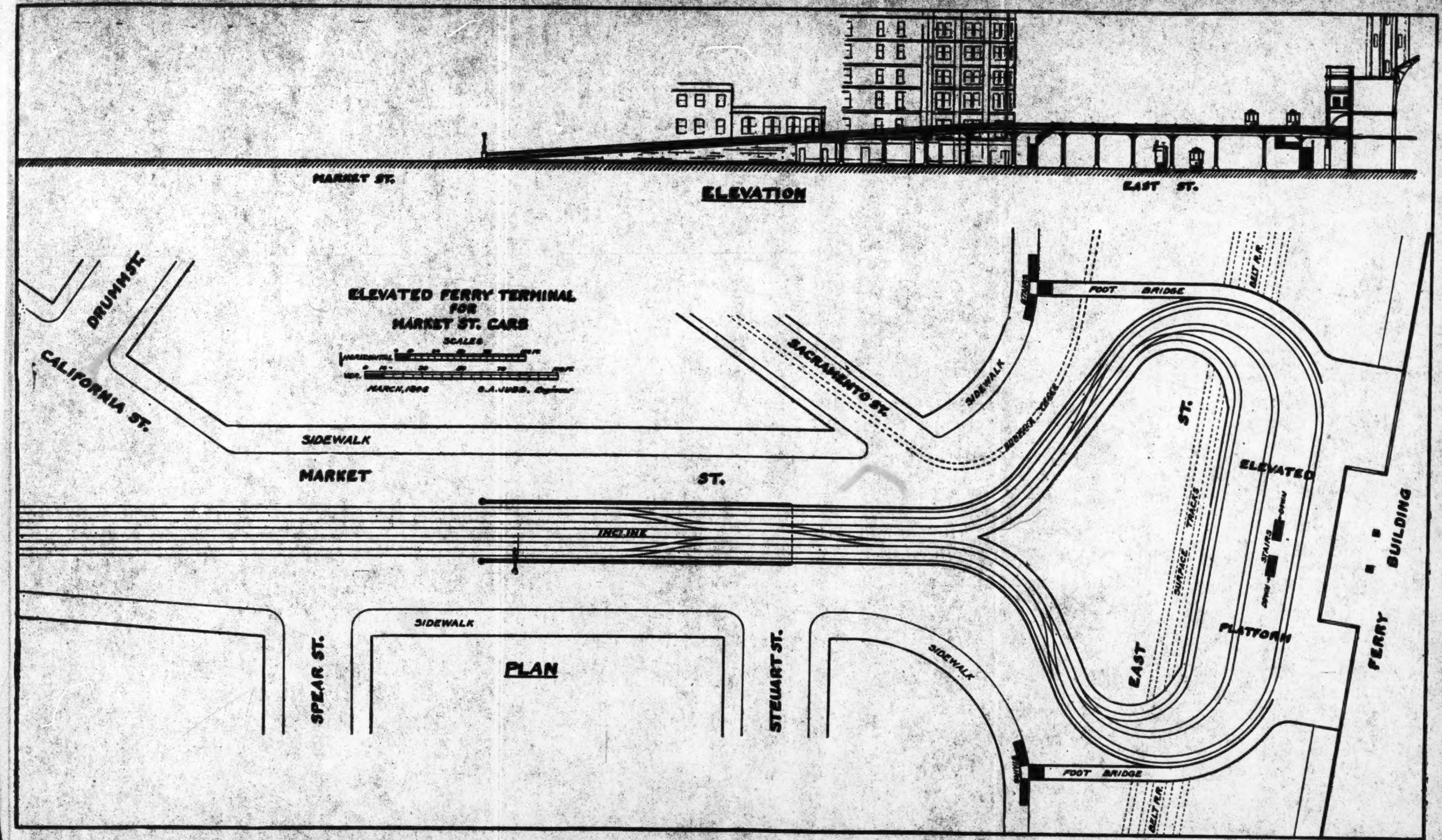
A part of this suggestion is to widen Market street from East to California street on the north side, and from East to Spear on the south side. At present from the curbstone to the body of the street cars is a distance of 16 feet, and we suggest that not less than 20 feet be added. We assume that there would be a platform six feet wide, from the body of the street cars, on the outer side of the loop, and that it would begin with the ascent and continue around the loop. This would reduce the free roadway on either side from 16 to 10 feet, and to avoid accidents and congestion there should be a free roadway on either side of the street—at least 30 feet wide.

None of the property required for this widening has very valuable improvements and we believe that this plan of the elevated loops and bridge for foot passengers separating the three classes of traffic into distinct and non-interfering lines offers the most permanent and practical solution of the present and increasing difficulty.

PART VI.

COST OF COMPLETE HARBOR.

We are now in a position to estimate the cost of the complete harbor, equipped with piers, docks and basins along the water front, from the Presidio to the San Mateo county line. In a previous section of this report (Part IV, page 49) we have indicated an arrangement of docks within these limits and which would accommodate an annual commerce of 30,000,000 tons. Following


ELEVATION
MARKET ST.
EAST ST.
ELEVATED FERRY TERMINAL
FOR
MARKET ST. CARS
SCALES
HORIZONTAL
VER.
MARCH, 1896
C.A. JUDD, Engineer
DRUMM ST.
CALIFORNIA ST.
SACRAMENTO ST.
SIDEWALK
MARKET
ST.
INCLINE
SPEAR ST.
STEUART ST.
PLAN
FOOT BRIDGE
STAIRS
BELT R.R.
BREAK CABLE
EAST
ST.
SURFACE TRACKS
ELEVATED
PLATFORM
FERRY
BUILDING

SKETCH FOR PROPOSED LOOP AT THE FERRY

that (Part V) we have discussed in detail several problems of construction work.

We here submit a detailed estimate of cost of all the work as shown upon the map, segregated by sections of the water front.

ESTIMATE OF COST BY DISTRICTS.

The following is an estimate of the cost of all the new work as shown on the map:

BOUNDARY LINE SAN MATEO COUNTY TO HUNTERS POINT.

Seawall 6400 feet @ $180	$1,152,000	
14 outside wharves 800x100	2,240,000	
6 outside wharves 570x100	684,000	
		$ 4,076,000

Inside South Basin.

7600 ft. inside wall @ $100	$ 760,000	
1 drawbridge	100,000	
7 wharves 400x100	560,000	
6 wharves 450x100	540,000	
1 wharf 500x100	100,000	
Dredging, 2,800,000 yds.	280,000	
		2,340,000

HUNTERS POINT TO NORTH SIDE ISLAIS CREEK.

Outer seawall 7600 ft. @ $180	$1,368,000	
17 wharves 800x100	2,720,000	
1 wharf 650x100	130,000	
1 wharf 500x100	100,000	
1 solid pier 1150x150 ft. @ $380	437,000	
		4,755,000

Inside India Basin.

5800 ft. inside wall @ $100	$ 580,000	
1 drawbridge	100,000	
3 wharves 450x100	270,000	
2 wharves 400x100	160,000	
4 wharves 500x100	400,000	
Dredging 2,700,000 yards	270,000	
		1,780,000

Inside Islais Basin.

Acquisition of the site	$1,000,000	
13,750 ft. inside wall	1,375,000	
9 wharves aggregating 9800 feet	1,960,000	
1 drawbridge	100,000	
Dredging	400,000	
		4,835,000

NORTH SIDE ISLAIS CREEK TO SOLID PIER AT CENTRAL BASIN.

5800 ft. seawall @ $180	$1,044,000	
1 solid pier 1500x150	570,000	
17 wharves 800x100	2,720,000	
		4,334,000

SOLID FILLED PIER AT CENTRAL BASIN TO CHANNEL STREET.

Seawall 3750 ft. @ $180	$ 675,000	
1 solid pier 1500x150 ft.	570,000	
15 wharves aggregating 12,950 ft.	3,405,800	
2 drawbridges	200,000	
2150 ft. extension seawall dock	387,000	
		5,237,800

CHANNEL STREET TO FERRY.

Seawall 5200 ft. @ $180	$ 936,000	
15 new wharves	1,937,000	
Removing old wharves	30,000	
		2,903,000

FERRIES TO SOLID FILLED PIER NEAR KEARNY STREET.

Extension 13 wharves 129x100 ft.	$ 335,400	
6 wharves 650x100 ft.	780,000	
		1,115,400

SOLID PIER KEARNY STREET TO VAN NESS AVENUE.

1 solid pier 800x150 ft.		
1 solid pier 1200x150 ft.		
2000 ft. @ $380	$ 760,000	
Seawall Taylor St. to Van Ness Ave., 3000 ft. @ $180	540,000	
3 wharves 650x150 ft.	390,000	
14 wharves 800x100 ft.	2,240,000	
		3,930,000

FORT MASON TO PRESIDIO.

Inside Improvements.		
*3 slips each 1600 ft. long, 200 ft. wide at bottom	$1,331,569	
Outside Work.		
†2750 ft. seawall @ $250	$ 687,500	
2 drawbridges	200,000	
8 solid piers each 600 ft. long	1,824,000	
		4,043,069
		$39,349,269
Contingencies 10%		3,934,926
		$43,284,195

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*No estimate for cost of real estate.

†Practicable but can be deferred.

NOTE.

The sound value of water front improvement and property owned by the State of California, which includes wharves, seawall, Ferry Building, Belt Railroad, real estate, etc., may be roughly estimated at $10,000,000. If to this be added the estimated cost of improvements as outlined in the foregoing pages, viz., $43,284,195, there results a total of $53,284,195.

As the annual commerce which may be handled over the water front as thus developed is estimated at 30,000,000 tons, the cost of the improvements at this port is therefore at the rate of $1.77 per ton of annual commerce.

This estimated is based on the assumption that the cylindrical piles shall be adopted as recommended in this report. If the type of pile now in use were employed in future construction $10,000,000 additional costs should be added to the above estimate, in which case the total cost would be about $63,000,000 and a rate per ton of annual commerce of $2.10.

The improvements at 17 foreign ports have cost in the aggregate $774,000,000, while the total annual tonnage handled at the same ports is 143,000,000 tons, or at the rate of $5.41 per ton of annual commerce.

PART VII.

FINANCING EXTENSION WORK.

In another part of this report it was estimated that by the year 1927 we should be prepared to handle a commerce of 13,000,000 tons annually. This will require about 60 wharves, averaging 600 feet in length, and about 21,000 linear feet of seawall. There are now 31 wharves; 29 additional are required and 19 existing wharves will have to be rebuilt. The State has constructed 9803 feet of seawall, an additional 1000 feet has been contracted for and is now being built, and nearly 11,000 feet more will have to be provided for.

For purposes of estimate it may be considered that seawall costs $180 per linear foot and wharves $250 per linear foot, or $150,000 per wharf. . The estimated cost of construction work necessary prior to 1927 would therefore be:

Seawall, 12,000 ft., @ $180	$ 2,160,000
48 wharves @ $150,000	7,200,000
Purchase of land near Islais Creek, Belt Railroad, dredging, etc.	1,500,000
Total	$10,860,000

ORDER IN WHICH UNDERTAKEN.

The localities at and the order in which the new work should be constructed will depend largely upon existing and probable requirements of this port in the next ten or fifteen years.

Seawall construction must precede that of wharves. The harbor lines should first be changed as the seawall must be located on the bulkhead line, and application to change the harbor lines is the very first requirement.

In that section of water front between Channel street and the ferries there are now 18 wharves, only four of which are of modern type. The old ones must soon be torn out and replaced by modern, permanent structures. A seawall nearly a mile in length will also have to be built there. Part of this work is now in progress. The area in front of China Basin cannot legally be used by the State for wharf purposes until the seawall just referred to has been completed. The work on this section is urgent, is the most important on the whole water front, and its completion should be hastened. The Belt Railroad should then be extended along that section and warehouse sites, which will then be reclaimed and will be owned by the State, should then be leased and become revenue producing property.

Simultaneously with work on this section it would be well to extend one or two sections of seawall south from China Basin and build wharves on these new sections as soon as practicable thereafter. This should be followed by wharf construction near Mission Rock in front of China Basin as soon as the seawall between Channel street and the ferries has been completed.

Submerged land near Islais Creek should be acquired and bulkheads along India street, First avenue South, Massachusetts street and both sides of Islais Creek channel as far west as Kentucky street should be built. The Islais Creek Basin should be dredged and the spoil deposited behind the bulkheads. This should be followed by the construction of one or more wharves in Islais Creek Basin, and then, if funds permit, by a further extension of seawall southerly from Central Basin.

An estimated cost of above work is herewith given:

5400 ft. seawall @ $180	$ 972,000
19 wharves @ $150,000	2,850,000
Belt Railroad, 5400 ft.	40,878
2000 ft. seawall south of China Basin	360,000
15 wharves between Channel street and south side Central Basin	2,250,000
Islais Creek Basin acquisition	1,000,000
Dredging this basin	400,000
Bulkhead at Islais Basin and in creek, 12,275 ft. @ $100	1,227,500
Wharf inside Islais Basin	150,000
2000 ft. seawall toward Islais Creek	360,000
7 wharves south Central Basin	1,050,000
Extension of wharves in Islais Basin	200,000
Total	$10,860,000

AMOUNT OF BONDS NECESSARY.

While the above work will be needed before 1927, it would be desirable to have it completed about the year 1920. Enough money cannot be spared from the revenues of the port to pay for the above work in the time mentioned. Money can be obtained by a bond issue of long term (75 years) State bonds bearing 4 per cent. interest. A sinking fund for their retirement at 2 per cent. annually to commence about the year 1935, and to continue for fifty years until the debt is extinguished, would be desirable.

At present, and until 1912, there must be paid annually $55,572 from the revenues of the port, interest and sinking fund on ferry depot bonds. A short term bond issue of $2,000,000 for seawall and appurtenances has also been authorized. These bonds bear 4 per cent. interest and carry about 6½ per cent. sinking fund for redemption. The interest and sinking fund together amounts to about $210,000 annually, which, added to the $55,572 above referred to, makes an annual charge on the revenues of $265,572. In addition the following deferred payment drafts must be paid:

June 20, 1908	$80,196 50
June 20, 1909	66,978 78
June 20, 1910	58,675 38
June 20, 1911	13,774 56
Total	$219,625 22

(See table II, col. 3, page —.) This leaves very little available for new construction work.

In the event that $10,000,000 long term State bonds should be authorized, they probably could not be issued before the year 1910, and should only be sold thereafter as rapidly as required to pay for work contracted for. In the meantime the $2,000,000 seawall bonds authorized will have been sold to pay for construction work in progress. As much of the $10,000,000 bonds should be used as might be necessary for the redemption or refunding of all previously issued or authorized short term bonds.

ANALYSIS OF EXPENDITURES.

With a view of determining the proportion of the harbor revenue which may be applied to new construction the following items of expenditures from 1863 to 1906 have been taken from the report of the Harbor Commissioners for 1904-06 and arranged as follows:

		Per Cent.
Cost of administration	$ 4,646,855	21.72
Construction and repairs	10,506,677	49.26
Seawall	2,803,738	13.14
Dredging	2,478,566	11.60
Belt Railroad	670,596	3.14
Miscellaneous	244,364	1.14
	$21,350,796	100.00

From the above and a study of the statistical chart herewith it is possible to estimate the revenue producing capacity of the San Francisco docks in the future.

In the period 1863 to 1906 the cost of administration (including salaries of Commissioners, secretaries, clerks, wharfingers and collectors; lawyers, fuel, rent, printing, stationery, etc.) has varied between the limits of 11.95% and 36.50% of the total gross revenue annually. In the past ten years, while the revenues have been increasing, the cost of administration has been decreasing. Effort should be made to keep down this cost so that it should not exceed 15% of the total revenue. In the reports of the Harbor Commissioners the construction and repair accounts have not been segregated. The cost of repairs and renewals of wharves has been very heavy, due principally to the perishable character of the structures. To ascertain the relative expenditures for repairs and renewals, it may be assumed that the 31 existing wharves and the paving behind the seawall has cost about $3,500,000, or about 16¼% of the total expenditures, viz., $21,350,000, shown in above table. Deducting 16¼% from the 49.26% for construction and repair account in the above table leaves 33% as the approximate former average cost of maintenance, renewal and repairs.

At present the gross income may be roughly divided into three nearly equal parts, one of which is available for maintenance, renewal, repair; another for new construction, interest and sinking fund; the remaining third covers administration, dredging, Belt Railway and miscellaneous.

As the new construction work is to be reasonably permanent, it may be possible eventually to reduce the expense of maintenance, renewal and repair to less than 20% of the gross income, but for purposes of estimate it has been assumed that the present cost of these items, viz., 33%, may in the next ten or eleven years, be reduced to about 25% of the gross income. If to this be added 15% for administration and 16% aggregate for dredging, Belt Railroad and miscellaneous, which probably cannot be reduced. there results 56% of gross income applicable to above items, and there remains 44% available for new construction, interest and sinking fund.

If to the 33% at present available for construction, interest and sinking fund there be added for 11 consecutive years 1% increase each year over that of the preceding year, the 44% above referred to will be available in the year 1919.

COMPARED WITH NEW YORK.

In connection with the preceding, an analysis of expenditures and revenue at New York is herewith given, taken from the recent reports of the Department of Docks and Ferries of New York city:

Total amount of dock bonds and corporate stock of the city of New York, issued from May 1, 1870, to Dec. 31, 1906		$78,071,500
RECEIPTS during the year ending Dec. 31, 1906.		
Revenue from rents, leases, wharfage, ferries, etc.	$ 4,390,033	
From corporate stock issued, from premiums on same, and work done for private parties	10,188,930	
		$14,578,963
Expenditures for year ending Dec. 31, 1906.		
Credit for sinking fund for redemption of city debt and for interest on same and to credit of dock fund	$ 4,390,033	
For construction, repairs, maintenance, including ferries, salaries, etc.	6,113,061	
For acquired property	4,075,869	
		$14,578,963

The total gross revenues from leased wharves and wharfage from ferry leases and franchises and from operating municipal ferries from 1871 to Dec. 31, 1905, was $62,332,582. During this period the expenses were divided as follows:

Administration.		
Salaries of Commissioners	$ 534,114	
Salaries secretaries, clerks, dockmasters, etc.	1,792,798	
Stationery and incidentals	415,614	
Engineers and subordinates	2,724,486	
		$ 5,467,012
Construction, including ferries		39,546,292
Repairs, including ferries		7,078,625
		$52,091,929
Cost of acquired property		19,314,384
Total		$71,406,313

Eliminating from the foregoing the cost of acquired property, there has been expended in 34 years about $52,092,000. From 1871 to 1877, inclusive, the construction and repair accounts were not segregated; from 1878 to 1905 inclusive they were separated and in said period the ratio of cost of construction to that of repairs was as 83:17. By applying this ratio during the period 1871-77 to above items of construction and repair, the figures in the table become as follows:

Cost of administration	$ 5,467,012	10.5% of whole
Cost of construction, including ferries	38,729,676	74.3% "
Cost of repair, including ferries	7,895,241	15.2% "
Total	$52,091,929	100.0%

On pages 85-86 of this report we have considered that for San Francisco the percentage of expenditures might be gradually apportioned as follows:

	Per cent.
Administration	15
Construction	44
Repairs	25
Other matters including Belt R. R. and miscellaneous	16

FORECAST OF RESOURCES.

Taking from the statistical chart estimates of annual revenue as a basis and applying thereto the percentages each year available above operating expenses and maintenance charges, as shown on page 86, it becomes possible to forecast the approximate sum available in each year for new construction.

These results are shown in the following three tables. The first shows the net income available by years from 1908 to 1950. The second is framed on the assumption that the only bonds sold in this period will be the $2,000,000 issue which is already authorized, and shows in tabular form the total amounts thus available for new construction each year, and the gross total at the end of each year for the period. From this it will be seen that the money which would be necessary for the new construction which we have outlined would not become available until many years after it was required, and during this time the commerce of the port would suffer from the lack of adequate facilities.

In table No. III we have assumed an authorized issue of $10,000,000 of 4% 75-year bonds, maturing in 1985, the first of which would be sold in 1910. The amounts thus available are set forth, by years. It is assumed further that these bonds would be sold in five annual installments: $4,000,000 in 1910 (part of this being used in refunding the previous bonds), $2,000,000 in each of the following two years, and then $1,000,000 each in 1913 and in 1914. At the end of 25 years a sinking fund is commenced, and a sum equal to 2 per cent. of the entire debt is set aside each year for the following 50 years. In 1935, as will be seen from the tables, the port revenue available will amount to a million dollars annually, and be sufficient to meet this charge, and to provide a considerable sum each year for further new work.

Under this plan the amount which we have estimated as necessary for the new construction work as outlined above, that is, $10,860,000, would be expended in full about the year 1917, and the larger portion in the years from 1910 to 1914, inclusive.

In estimating the gross revenue of the port the same figures are used both in table II, representing the conditions under a bond issue of $2,000,000, and in table III, which is based on the presumption of an issue of $10,000,000. In actual practice it would probably be true that the gross revenues would be greater in the latter case, as there would be more wharf space from which to derive rentals, and the discharging and loading of vessels would be less congested. It is also true that such a favorable condition would attract increased trade to the port; but for the purposes of estimate the revenues have been computed in each case on the forecast of future trade as shown on the statistical chart, and irrespective of the relative abundance or scarcity of dock accommodations.

Assuming that the increase of commerce will be about as shown upon the statistical chart, a $10,000,000 long-term bond issue will be ample to meet the immediate requirements and also to provide for the intervening years, says from 1920 to 1950. Should the rate of growth be greater than the predicted one, there would be an increased revenue out of which would come the greater amounts for construction. In other words, this plan appears to be one that will meet the immediate requirements and provide accommodation for future commerce slightly in advance of actual necessity up to the year 1950.

FORECAST OF HARBOR REVENUES.

TABLE I.

SHOWING PROBABLE NET ANNUAL INCOME AVAILABLE FOR NEW CONSTRUCTION WITHOUT SALE OF BONDS.

YEAR	Probable Gross Income for Year	Estimated Percentage Available for New Work, Interest, and Sinking Fund	Estimated Amount Available Each Year for New Work, Interest, and Sinking Fund
1908	$ 972,160	33	$ 320,800
1909	1,003,600	34	352,200
1910	1,035,600	35	362,400
1911	1,068,500	36	384,600
1912	1,102,500	37	407,900
1913	1,137,000	38	432,000
1914	1,173,000	39	457,400
1915	1,210,000	40	484,000
1916	1,247,000	41	511,300
1917	1,286,000	42	540,100
1918	1,325,000	43	569,700
1919	1,366,000	44	601,000
1920	1,408,000	“	619,500
1921	1,450,500	“	638,200
1922	1,494,000	“	657,400
1923	1,539,000	“	677,200
1924	1,586,000	“	697,800
1925	1,633,000	“	718,500
1926	1,681,000	“	739,600
1927	1,731,000	“	761,600
1928	1,782,000	“	784,100
1929	1,834,000	“	807,000
1930	1,888,000	“	830,700
1935	2,176,000	“	957,400
1940	2,500,000	“	1,100,000
1945	2,864,000	“	1,260,100
1950	3,274,000	“	1,440,500

FORECAST OF HARBOR REVENUES.

TABLE II.

SHOWING PROBABLE RESOURCES BY YEARS AVAILABLE FOR NEW CONSTRUCTION UNDER PRESENT PLAN OF $2,000,000 BOND ISSUE.

Year.	For New Work, Interest and Sinking Fund	Charges for Interest and Sinking Fund	Balance for New Work	Bonds to be Sold	Amount Available Annually	Total Expended at End of Each Year
1908	$ 320,800	$185,887	$134,913	$ 250,000	$ 634,913	$ 884,913
1909	352,200	334,000	18,200	500,000	1,268,200	2,153,113
1910	362,400	325,697	36,703	1,250,000	36,703	2,189,816
1911	384,600	280,796	103,804			2,293,620
1912	407,900	267,622	140,278			2,433,898
1913	432,000	211,450	220,550			2,654,448
1914	457,400	211,450	245,950			2,900,400
1915	484,000	211,450	272,550			3,172,950
1916	511,300	211,450	299,850			3,472,800
1917	540,100	211,450	328,650			3,801,450
1918	569,700	211,450	358,250			4,159,700
1919	601,000	211,450	389,550			4,549,250
1920	619,500	211,450	408,050			4,957,300
1921	638,200	211,450	426,750			5,384,050
1922	657,400	211,450	445,950			5,830,000
1923	677,200	211,450	465,750			6,295,750
1924	697,800	211,450	486,350			6,782,100
1925	718,500					
1926	739,000					
1927	761,600					
1928	784,100					
1929	807,000					
1930	830,700					
1935	957,400					
1940	1,100,000					
1945	1,260,100					
1950	1,440,500					

In the above fifth column it is assumed that of the authorized $2,000,000 bond issue, $250,000 of which was sold in 1907, $500,000 will be sold July 1, 1908, and $1,250,000 July 1, 1909. In col. 3 figures for '08, '09, '10 and '11 include deferred payment drafts maturing in these years.

FORECAST OF HARBOR REVENUES

TABLE III.

SHOWING PROBABLE RESOURCES BY YEARS AVAILABLE FOR NEW CONSTRUCTION UNDER PROPOSED PLAN OF $10,000,000 BOND ISSUE.

Year	For New Work Interest and Sinking Fund	Charges for Interest and Sinking Fund	Balance for New Work	Bonds to be Sold	Amount Available Annually	Total Expended at End of Each Year
1908 1909	(Same as under $2,000,000 issue, which with other outstanding indebtedness would be refunded in 1910 under this plan.)					
1910	$362,400	$160,000	$202,400	$4,000,000	$4,202,400	$4,202,400
1911	384,600	240,000	144,600	2,000,000	2,144,600	6,347,000
1912	407,900	320,000	87,900	2,000,000	2,087,900	8,434,900
1913	432,000	360,000	72,000	1,000,000	1,072,000	9,506,900
1914	457,400	400,000	57,400	1,000,000	1,057,400	10,564,300
1915	484,000	400,000	84,000		Same as in col.4	10,648,300
1916	511,300	400,000	111,300			10,759,600
1917	540,100	400,000	140,100			10,899,700
1918	569,700	400,000	169,700			11,069,400
1919	601,000	400,000	201,000			11,270,400
1920	619,500	400,000	219,500			11,489,900
1921	638,200	400,000	238,200			11,728,100
1922	657,400	400,000	257,400			11,985,500
1923	677,200	400,000	277,200			12,262,700
1924	697,800	400,000	297,800			12,560,500
1925	718,500	400,000	318,500			12,879,000
1926	739,000	400,000	339,000			13,218,000
1927	761,600	400,000	361,600			13,579,600
1928	784,100	400,000	384,100			13,963,700
1929	807,000	400,000	407,000			14,370,700
1930	830,700	400,000	430,700			14,801,400
1935	957,400	*600,000	357,400			17,070,000
1940	1,100,000	600,000	500,000			19,220,000
1945	1,260,100	600,000	660,100			22,120,000
1950	1,440,500	600,000	840,500			25,870,000

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*2% Sinking Fund commenced in this year, $200,000.

Senate Constitutional Amendment No. 29. which will amend Section 1. of Art. 16. of the Constitution of California

Provides, for the issuing of bonds for a term of 75 years. and providing that a Sinking Fund on such bonds shall commence on the 19th year after date of issue of same.

When said Amendment is adopted by a vote of the electors of California. Table No. III above would be amended as follows: No change until the year 1930. when the Sinking Fund would begin—the last five lines in column 7 would read as follows:

1930......	$14.600.700
1935......	16.069.950
1940......	18.205.000
1945......	21.105.000
1950......	24.707.000

PART VIII.

SUMMARY AND CONCLUSION.

The present wharves are inadequate for an increased commerce.

New wharves and additional seawall should be constructed in advance of the immediate requirements of commerce.

Harbor lines should be modified as soon as practicable. Application to change these lines and to build several solid piers extending outside the pierhead line should be made to the Secretary of War.

Funds from existing dock revenues are not sufficient to make the improvements as rapidly as required. The present port charges should not be increased. The improvements to be made in the next ten years will cost between ten and eleven millions of dollars. Funds for this purpose may be obtained by an issue of $10,000,000 four per cent. 75-year State bonds, sinking fund for their redemption to begin 25 years after their first issue.

Legislative action and a vote by the people of the State will be necessary to authorize the bond issue. It should also be requested for authority to construct a seawall west of Taylor street to Van Ness avenue and from Fort Mason to the Presidio.

Warehouses at the head of wharves are essential. A change in the bulkhead line as recommended would afford suitable warehouse sites.

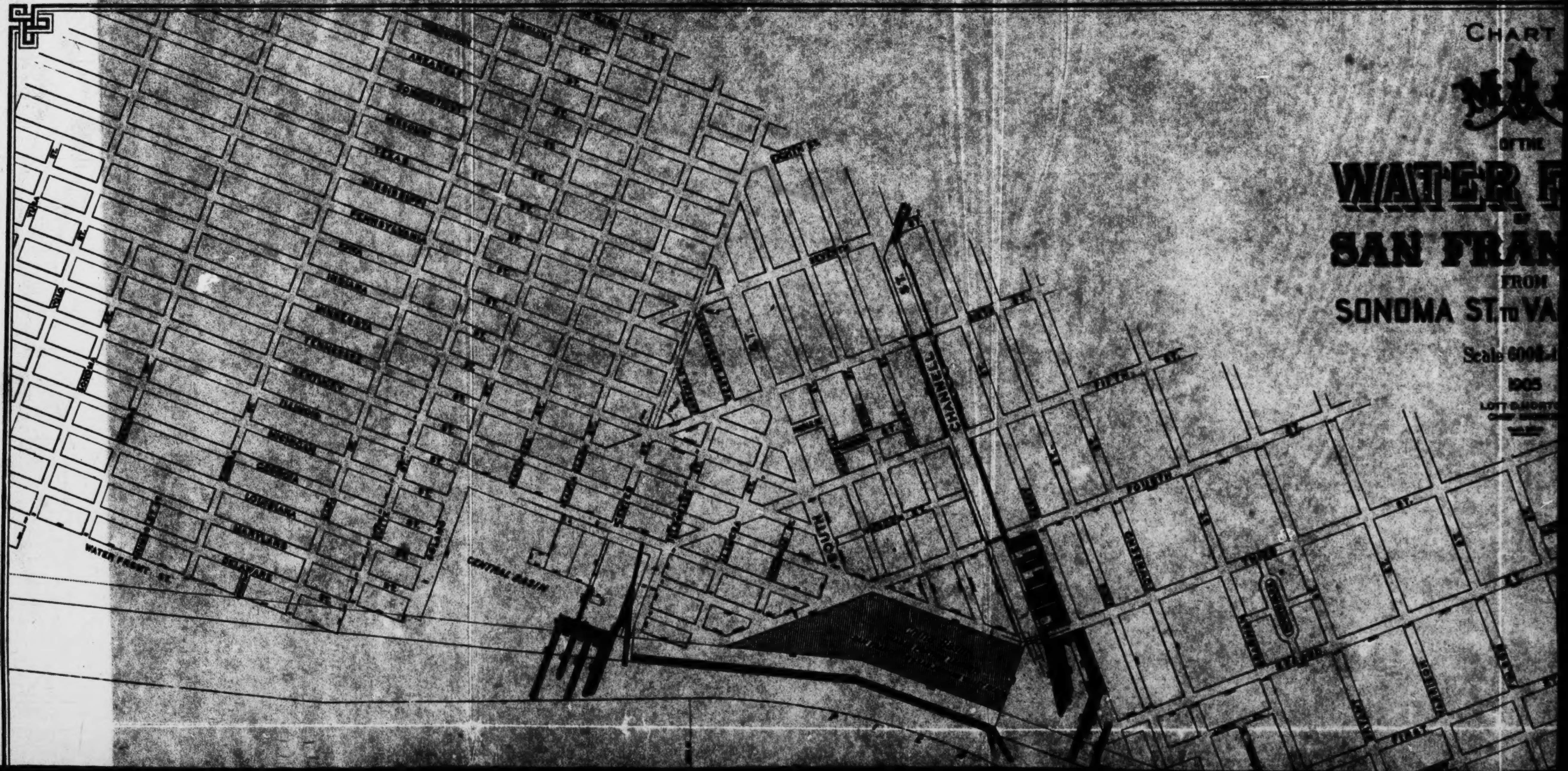
An improvement in the character and reduction in the cost of the permanent piling under the new wharves is worthy of careful consideration. A method has been devised, explained and illustrated in this report, to which attention is invited. More than 100,000 piles will be required in the construction of all the piers designed for the water front of San Francisco. Each pile of the suggested type has superior supporting power and will cost about $100 less than those of the type now in use. This will result in a total saving of $10,000,000, or the amount of the bond issue we have advised.

Accompanying this report is a chart showing an arrangement of wharves, and several solid piers, that may be constructed within the harbor lines along the new water front of San Francisco. They are believed to be capable of handling an annual commerce of about 30,000,000 tons.

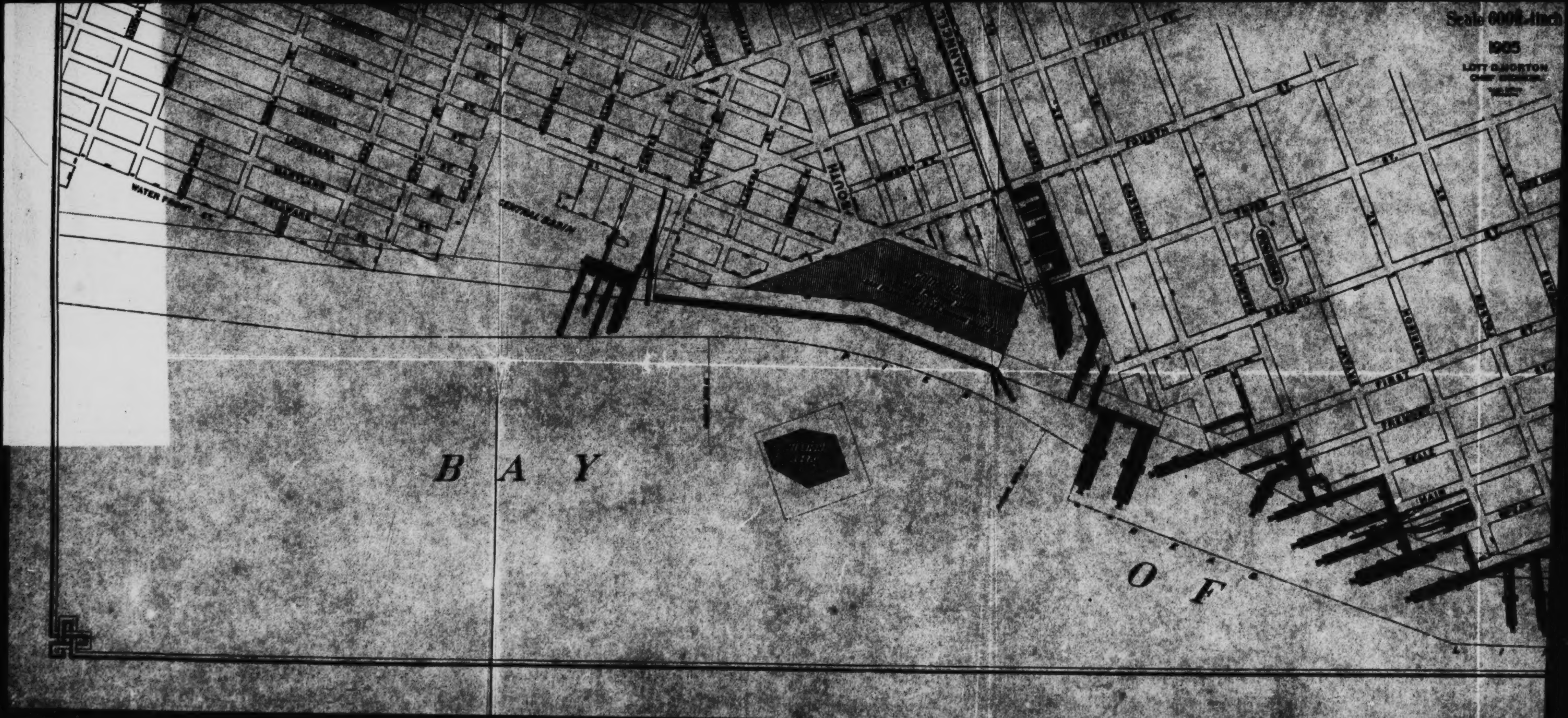
Thus with an expenditure, small in comparison to that which has been made at other great ports, and which will eventually be returned from the revenues derived from the docks themselves. this port may be equipped to accommodate and invite the ever increasing commerce of the world.

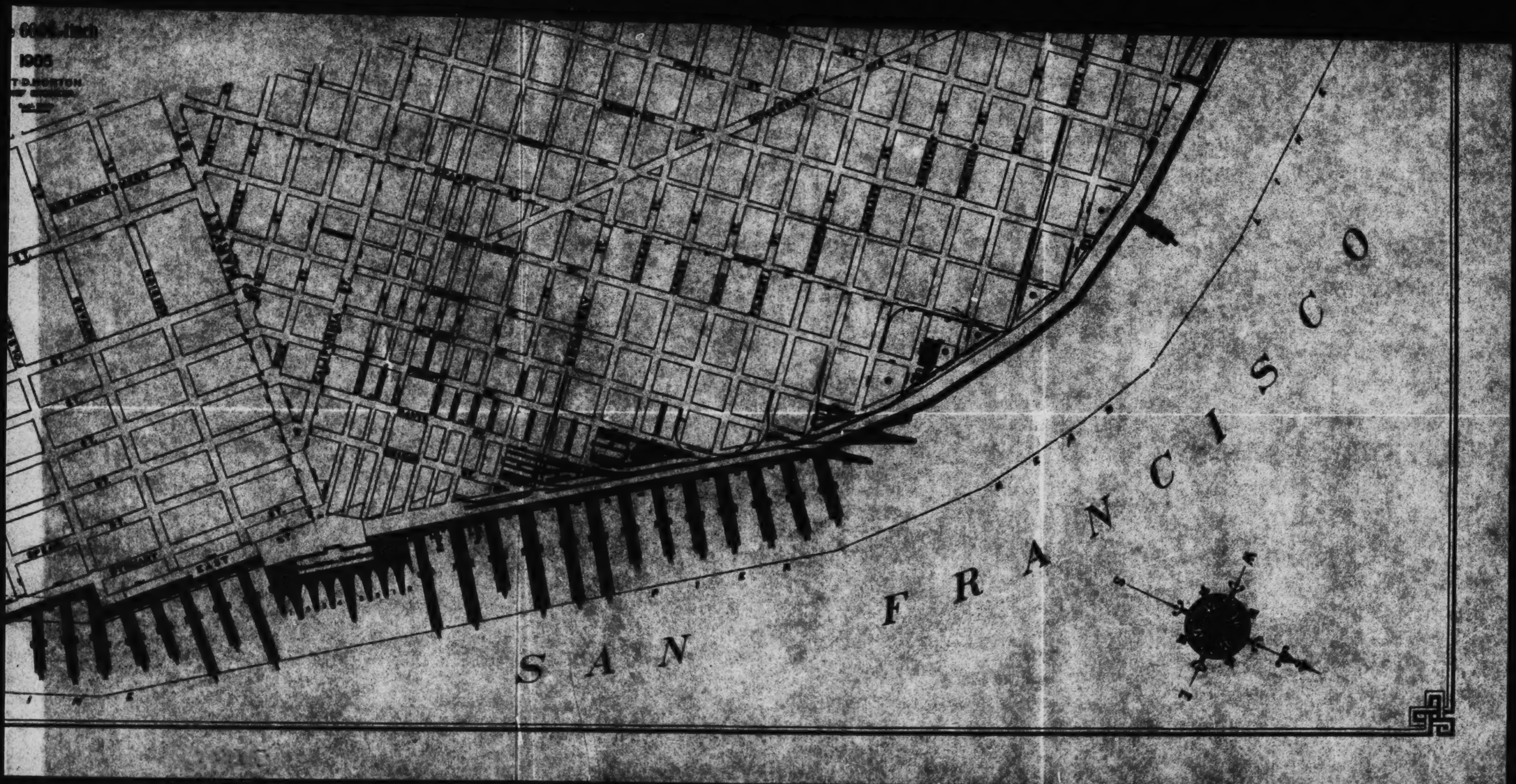
(Signed)

LUTHER WAGONER,
Member American Society of Civil Engineers
WM. H. HEUER, Col. U. S. A.,
Consulting Engineer.

CHART
MAP
OF THE
WATER F
OF
SAN FRAN
FROM
SONOMA ST. TO VA
Scale 600ft
1905
LOTT D. NORTO
CHIEF ENGINEER
ARKANSAS
CONNECTICUT
MISSOURI
TEXAS
MISSISSIPPI
PENNSYLVANIA
IOWA
INDIANA
MINNESOTA
TENNESSEE
KENTUCKY
ILLINOIS
MICHIGAN
GEORGIA
LOUISIANA
MARYLAND
DELAWARE
WATER FRONT ST.
CENTRAL BASIN
CHANNEL
SOUTH
FIFTH ST.
FOURTH
FIRST

ART 1
AP
OF THE
R FRONT
ANCISCO
FROM
TO VAN NESS AVE.
1905
VAN NESS AVE.
MARKET
S C O

Scale 600ft.-1inch
1905
LOTT D. MORTON
CHIEF ENGINEER
WATER FRONT ST.
CENTRAL BASIN
FIRST
FREMONT
BEALE
MAIN
B A Y
O F


1905
T D. MORTON
EAST
SAN FRANCISCO

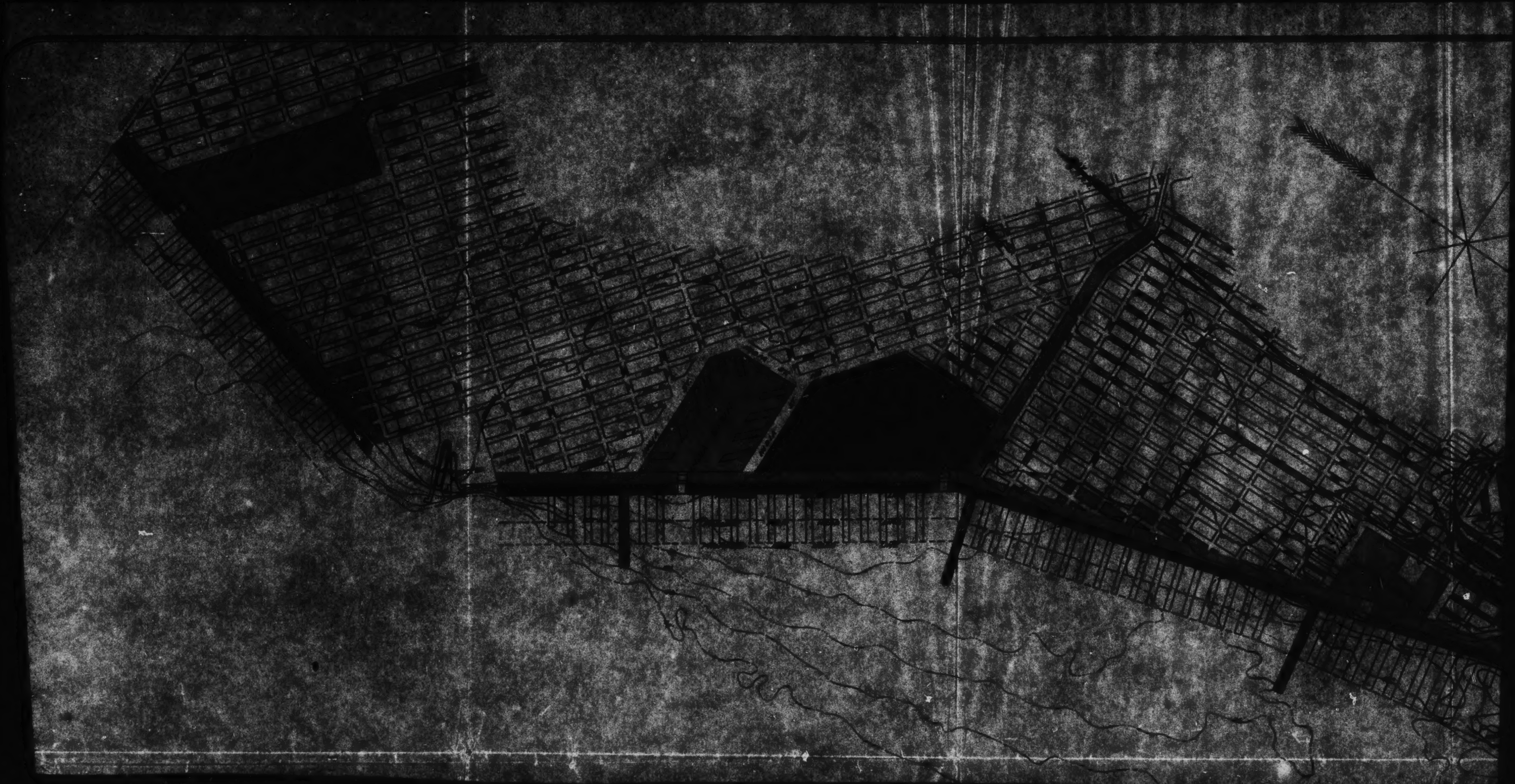
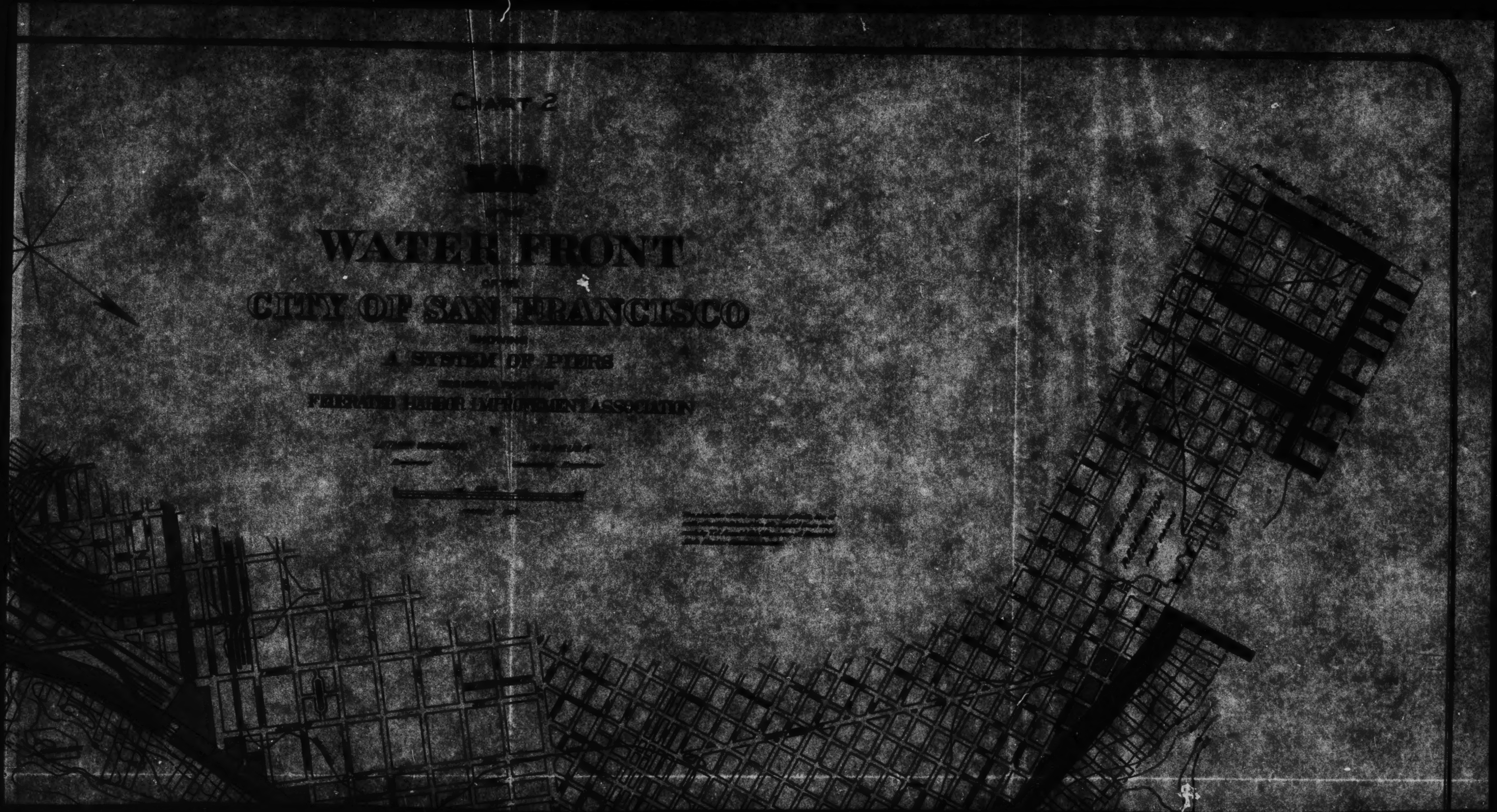


CHART 2


MAP
OF THE
WATER FRONT
OF THE
CITY OF SAN FRANCISCO
SHOWING
A SYSTEM OF PIERS
FEDERATED HARBOR IMPROVEMENT ASSOCIATION

Pink tint represents property owned by State of California.
Olive Green tint represents property recommended to be acquired by State of California.